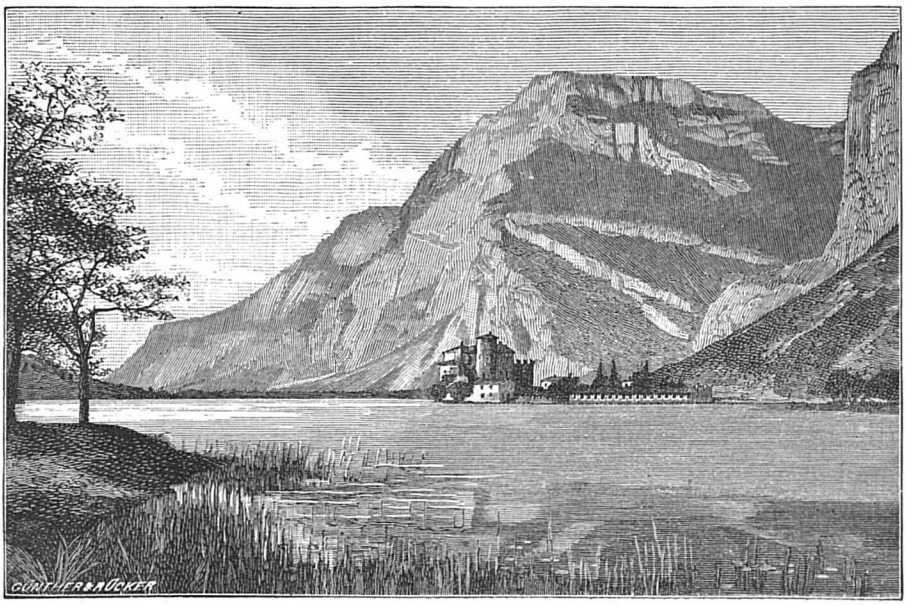
rugged rock, especially on the western side, space for luxuriant orange and citron gardens. A range of beautiful highlands surrounds the southern part, and is gradually lost as it assumes the character of the Italian plain. Lake Garda (141 square miles) is the largest of the Alpine lakes, with the exception of Constance and Geneva. It lies lowest of all, being only 154 feet above the sea, and has a depth of 964 feet; its bottom lies 810 feet below the surface of the sea. Tyrol claims the northern end of the lake, where, embosomed in fragrant citron-groves, Riva (German Reif, 173 ft.), and the smaller town of Torbole (258 ft.), stand in the "Garden of Austria;" the rest belongs to Italy. Limone stands on the western shore, Tremosine high up among the mountains, Gargnano at one of the most beautiful points, and the exquisitely placed village of Salo in a deep bay; on the eastern bank are the old town of Malcesine, and the village of Garda on a bay, giving its name to the lake, and Bardolino. The long, tongue-like peninsula, Sermione (Sirmio), divides the southern end of Lake Garda into two portions. On this peninsula the Roman poet Catullus retired to sing his elegies, and at a later period, Charlemagne and the mighty race of the Hohenstaufen held communion with nature in this lovely spot. Desenzano lies in the south-western bay of the lake, and the little Italian fortress, Peschiera, in the south-eastern corner.

(*c*) The ORTO D'ABRAMO GROUP (147 square miles) is bounded on the west by the Sarca Valley from Lake Garda to Le Sarche, north by the road which leads from Le Sarche to Trent, east by the valley of the Etsch from Trent down to Ravazzone, and south by the Val Comeraso and the saddle of Nago, as far as Torbole; it stands entirely in Tyrol. The south-eastern part consists of tertiary rocks, the north-western of the Jura formation. The mean height of the crest is 2839 feet, the whole being far below the snow-line. The main ridge has first a south-south-west and north-north-east direction, then directly north. At the point where the direction changes, the splendid Orto

d'Abramo (Abraham's Garden, 7138 ft.) rises, a field sacred to botanists, and the highest point of the group. It is an island of Jura limestone, surmounted by nummulite limestone resting on strata of oolitic limestone and dolomite. Monte Bondone (6889 ft.), north-east of the Orto d'Abramo, affords a fine view over the Trent district. The Cavedine Valley begins at the Orto d'Abramo and extends northwards; the Cavedine Lake does



Lake Toblino with the Castle of Toblino.

not lie in it, but on the further side of the ridge, which bounds it on the west. The stream of the Cavedine Valley also goes into the Toblino Lake, and the stream from the latter flows to the Cavedine Lake, the waters of which turn towards the Sarca. The beautiful Toblino Lake is adorned by the Castle of Toblino (786 ft.). The road which connects the Seethal and Judicarien with Trent passes its narrowest part. The continuation of this road climbs over the saddle of Vezzano (1583 ft.), and passes through the wild ravine, the Buco de Vela, between overhanging rocks.

(*d*) The GROUP of MONTE BALDO (191½ square miles) is bounded on the north by the saddle of Nago and the Val Comeraso, on the east by the Etsch Valley, from Ravazzone downwards; on the south by the plain of Upper Italy; and on the west by Lake Garda. Monte Baldo forms the conclusion of the range of limestone Alps on the right bank of the Etsch. The length of its base, from Nago to the outlying range of S. Virgilio, reaches 23½ miles, and its almost unvarying breadth, seven miles. Monte Baldo rises steeply from the wild Comeraso Valley, which contains the island-studded lake, the Loppiosee (662 ft.), and through which a carriage-road leads from the Etsch Valley, over the saddle Von Nago (the watershed of San Giovanni, 1048 ft.) to Torbole. It maintains an almost constant direction from north to south till it sinks towards the fruitful plain of Caprino. The eastern side of the chain contains a series of plateaux and terraces, having numerous villages and Alpine pastures, which, however, form steep precipices towards the valley of the Etsch. The western side is composed, in the higher portions, of bare slopes and gorges, with wild torrents which are swollen with the rain in winter, and are dried up in the hottest part of the summer. The situation of Monte Baldo, which projects towards the south, and its position midway between the high Alps and the Italian plain, permits magnificent views to be obtained from its highest peaks. The flora and fauna of both north and south are found here, and the district forms a fine field of discovery for the geologist and the botanist. The peak of the Altissimo (6790 ft.) rises near the northern end of Monte Baldo in Tyrol. From here the boundary between Tyrol and Italy runs along the ridge as far as the Acquenere, whence it descends eastward over the Monte Fassole (5309 ft.) to the Etsch. Immediately south of the Altissimo the Bocca di Navene (4968 ft.) forms the only deep saddle of the whole chain. In the middle of this rises Monte Maggiore (7215 ft.), the highest peak of Monte Baldo. The view from Monte Maggiore, though not so beau-

tiful as that from Altissimo, is more extensive, and includes the glacier region of the Adamello and Presanella, and the Brenta group.

Before concluding the description of the Central Alps we must glance at the stretch of the Etsch Valley lying between San Michele and the plain. The stream flows through the dolomite district of Southern Tyrol, between the groups of the Brenta, the Orto d'Abramo, and Monte Baldo on the west, and the Lessinian and Cadoric Alps on the east. Below San Michele, where the direction changes from north-north-east and south-south-west to south, the Nos empties its icy waters into the Etsch. Its ravages are restrained by huge dams; and the waters of the marsh, the Deutsch Metz (Mezzo Tedesco), are drained away by ditches, thus converting what was formerly a fever-laden fen, into a fruitful plain. From La Nave downward the valley of the Etsch resembles a garden, in which mulberry-trees, garlanded with the wild vine, alternate with peach and almond-trees, among the foliage of which may be seen churches, villas, and castles, the whole being overshadowed by towering walls of grey limestone. Lavis (743 ft.) stands picturesquely in the bay at the mouth of the Val Cembra, out of which the strong stream of the Avisio flows. Then the valley is closed by a mass of houses surrounded by strong walls, and dominated by the high dome of a cathedral. This is Trent (Roman *Tridentum*, Ital. Trento, 623 feet), formerly the wealthiest and most important town of Tyrol, from which the Italians call the valley from San Michele downwards, the "Agro Trentino." At Calliano (589 feet), where the valley contracts and turns to the west, there are the evidences of a former landslip. From here to the Italian boundary the lower valley of the Etsch is called the Val Lagarina; it is rich in southern vegetation and has good wine. The river again takes a southerly direction at Rovereto (Lat. *Roburetum*, Germ. Rofreit, 710 ft.), a busy town situated in the middle of a great basin. On the opposite slope of

the valley, the town of Isera (794 ft.), famed for its wine, is built in terraces. The valley of the Etsch, which up to this point is like a garden, is interrupted by a rocky waste just beyond Mori (570 ft.), caused by the *débris* of a terrible landslip which is said to have occurred in the year 883, and is called the Slavini di San Marco, from the village of San Marco (535 ft.), which lies on the further side of the slip. The broad basin of Rovereto ends with the old fortress Serravalle, and the valley then becomes narrower. The Italian boundary is crossed below Ala (463 ft.), the last Tyrolean town, and the river from this point is called the Adige. The mountain ridges gradually decrease on either side; but what the flanks of the valley lose in height, they gain in steepness, as they approach nearer to each other. Next we come to the Veronese or Berner Clause (Chiusa di Verona), a passage cut by the Adige through the last ring of the Alps. This passage is of a peculiar kind; the sides are not high, but are perfectly bare and smooth, as if hewn out, and the strong stream leaps through the confined space between the rocks; no earth is to be seen, the road being cut in the rock high above the stream, and looking like a strip of ribbon on the side of the ravine; below it is the railway. Soon, however, the gorge opens out suddenly among the soft hills; the Adige turns to the west, and leads us to the beautiful and venerable town of Verona (167 feet), standing in an exquisite position at the foot of the Alps, looking over the distant plain, and having the luxuriant hills as a foreground, and behind the majestic mountains.

## CHAPTER VIII.

### TOPOGRAPHICAL DESCRIPTION OF THE ALPS.

### III. The Eastern Alps.

The Eastern Alps extend eastwards from the Brenner to the Hungarian plain, the spurs reaching to the Middle Danube. The boundary on the side next to the Central Alps is defined by the Inn, the Sill, the Brenner, the Eisak, and the Etsch; they extend northward to the Bavarian plain, and eastward from the Inn to the valley of the Danube, where they approach the secondary ranges of Germany; on the south they are surrounded by the Venetian and Lombardian plains, but east of the Isonzo they meet the Karst range, from which they are separated by the rivers Istria, Laibach, and Save. The extensive outrunners to the east reach as far as the Danube at four different points, at three of which they face the peaks of the Carpathians. Klöden estimates the area of the Eastern Alps, including their eastern spurs, at 50,204 square miles. Leipoldt gives the area, without the spurs, as 31,577 square miles. They belong almost entirely to Austria, filling the eastern half of Tyrol, the whole of Salzburg, Upper and Lower Austria, as far as the Danube on the north, the whole of Carinthia and Styria, the north of Görz-Gradisca, and the north-west of Carniola, which are thence called the Austrian Alplands, of course including West Tyrol and Vorarlberg. The eastern outrunners extend over a great part of the south-west of Hungary, and over the whole of the north of Croatia-Sclavonia. The northern zone of the Eastern Alps also enters Upper

Bavaria, between the Inn and the Salzach, while the outer part of the southern zone, between the Adige and the Isonzo, belongs to Venetia.

Ritter has found the prevailing characteristic of the Eastern Alps to be the parallel arrangement of the chains as a whole, while the Central Alps present a picture of wild, rugged irregularity. The parallel chains of the Eastern Alps have a compact form, and thus present greater difficulty of traffic than the Central Alps, although their passes are lower and more convenient, for here several high chains have to be traversed one after another, or several collateral valleys ascend one above another like terraces. The parallel arrangement of the chains of the Eastern Alps arises from the occurrence of two broad longitudinal valley-troughs, which, however, are cut up by transverse saddles into separate river valleys. The more northerly of these valley-troughs is formed by the longitudinal valleys of the Inn, the Salzach, the Enns, and the Styrian Sala, the more southerly by the valleys of the Rienz and the Drave. A third, though lower, may be added, in the valley of the Mur and Mürz. The latter begins under the thirteenth meridian east of Greenwich. It is there also that the chains of the Eastern Alps begin to diverge, so that from that point towards the east, the breadth of the Alpine system steadily increases. The breadth of the Eastern Alps between Salzburg and Gemona on the Tagliamento, is not quite 112 square miles; between the northern end of the Wienerwald and Dugoselo (east of Agram) it is 174 square miles. The valleys grow constantly wider towards the east, and the mountains proportionately lower. The mountain folds appear to be pressed more closely together in the Central Alps, and are therefore lifted higher than in the Eastern Alps. The decrease in the height of the mountains in their eastern course is so considerable, that the high Alp character entirely disappears, and in its place are secondary mountains and wooded highlands, which in some places gradually sink into the plain.

The Alpine chains begin to lose their gigantic character east of longitude 13° E. The central chain, especially, soon sinks to a moderate height, no peak rising above the snow-line. Glaciers are found only in the northern and southern limestone chains, and are there of a limited size. All the rest is a mountain range of medium height, interspersed with broad plains and fields fit for cultivation.

The decrease in height of this range towards the east will be clear on observing their orometric values. The mean height of the "socle" of the Hohen Tauern is 4232 feet, of the Niederen Tauern, 3659 feet, of the Hochswab Group, 2367 feet, of the Wechsel, 1687 feet; the relative mean heights of the crests, for the same groups, are respectively 4708 feet, 2994 feet, 2242 feet, and 2110 feet. The heights of the peaks and of the saddles decrease in the same proportion towards the east. There is not very much difference between the heights of the passes and those of the crests, but the heights of the peaks are often considerably greater than those of the crests. The finest peak of the Eastern Alps, however, the Gross Glockner (12,455 ft.), does not approach the loftiest points of the Western and Central Alps in height. According to Leipoldt the absolute mean height of the crest, for the whole of the Eastern Alps, is 6024 ft. The snow-line ascends towards the west with the decrease in height of the range, and the broadening of the valleys, which tend to isolate the high parts of the crest. While in West Tyrol the lower snow-line does not rise higher than 9551 feet, it lies, according to Sonklar, at 9590 feet in the Hohen Tauern.

The Eastern Alps, like the Central range, may be divided into three zones—a crystalline central zone, and a northern and southern limestone zone. The boundaries agree in the main with the great longitudinal valley furrows already mentioned. The central zone is separated from the northern zone by the Ziller Valley from the mouth of the river to Zell, by the Gerlos Valley, the Gerlos Pass, the Salzach Valley as far as St. Johann,

the Wagreiner Höhe, the Enns Valley as far as Lietzen, the Palten Valley, the Walder Höhe, the Liesing Valley, the Mur Valley from St. Michael to Bruck, the Murz Valley up to Mürzzuschlag, the Fröschnitz Valley, the Semmering Pass, the Schwarza and the Leitha. The boundary between the central zone and the southern zone is formed by the valley of the Rienz, the Toblacher Feld, and the valley of the Drave to Warasdin. It is worthy of remark that these boundary-lines are drawn from an orographical, as well as from a geological point of view, and do not therefore completely separate the zones of rock from each other. The finest part of the Kitzbühler and Salzburg Alps, for instance, as well as a portion of the North Styrian Alps, north of the central zone, belong to the crystalline mountains, as do also the granitic Bacher Gebirge to the south of the Drave.

Lakes abound only in the western part of the northern zone; large lakes are very rare in the central and southern zones, except in Carinthia, in the central zone.

The central zone of the Eastern Alps is divided into the following groups:—(1) The Zillerthal Alps, (2) the Hohen Tauern, (3) the Niederen Tauern, (4) the primitive Alps of Carinthia and Styria, (5) the Styrian Nieder Alps. In the northern zone are:—(1) The Kitzbühler Alps, (2) the Salzburg Alps, (3) the Salzkammergut and Enns Alps, or Upper-Austrian Alps, (4) the North Styrian Alps, (5) the Lower Austrian Alps, The southern zone includes:—(1) The Lessinian Alps, (2) the Cadoric, or South Tyrol dolomite Alps, (3) the Carnic Alps, (4) the Karawankas, (5) the Venetian Alps, (6) the Bacher Gebirge, (7) the Santhaler or Steiner Alps, (8) the Triglav Group, or Julian Alps. To these may be added the eastern outrunners:—(1) The Rosalie and Leitha Mountains, (2) the Styrian Highlands, (3) the Bakony Forest, (4) the Pannonian or Lower Hungarian Highlands, (5) the Highlands of Cilli, (6) the Mountains of Croatia and Sclavonia.

### (*a*) The Central Zone of the Eastern Alps.

1. The Zillerthal Alps extend northwards to the valley of the Inn, from Innsbruck to the mouth of the Ziller Valley, eastward to the Ziller Valley, the Gerlos Valley, the Gerlos Pass, the upper valley of the Salzach, the Krimml Valley, the Birnlücke and the Ahren Valley, southward to the Rienz, westward to the Eisak Valley, the Brenner Pass, and the Sill Valley as far as Innsbruck. According to Leipoldt they cover an area of 980 square miles, and belong to Tyrol, with the exception of a small portion in the east, which belongs to Salzburg. Though the Zillerthal Alps may be surpassed in massiveness and rugged grandeur by the Ötzthal and Ortler Alps, they are more than equal to these in grace and loveliness, as well as in their variety of arrangement. This group is, as a whole, constructed of primitive rocks, only small portions on the borders being composed of sedimentary or volcanic formations. The interior of the range is composed of central gneiss, which extends eastward to the Hohen Tauern. Mica-schist lies on this to the south, then clay-slate, then mica-schist again to the south-east, and finally a zone of granite. In the north, the central gneiss is bordered by a band, generally double, of granular limestone, which is followed by clay-slate. Sonklar divides the Zillerthal Alps into two groups, the Tuxer Alps in the north, and the Zillerthal Alps proper in the south, which are separated from each other by the Ziller Valley from the point where the Gerlos Valley opens into it, to the Zillergrunde, by the Zemm Valley and the Zamser Valley.

(*a*) The Tuxer Alps are bounded on the north by the Inn from Innsbruck to the mouth of the Ziller Valley, on the east by the Ziller Valley up to the Zillergrunde, on the south by the Zemm Valley, the Zamser Valley, the Pfitscher Joch, and the Pfitscher Valley, on the west by the upper valley of the Eisak, the Brenner Pass, and the Sill Valley. The southern portion

has a considerable extent of glacier, and, together with the branches extending into the valley of the Inn, attains a great height. The main crest of the Tuxer Alps begins with the Grünberg (9394 ft.), above the mouth of the Tuxer Valley, and thence extends to the south-west as far as the Saun Joch (6831 ft.) at Sterzing, having a length of twenty-one miles, and a mean height of 9419 feet. The height steadily increases in a south-westerly direction from the Grünberg, which is succeeded by the Lange Wand (9664 ft.), the Rosskopf (9728 ft.), the Hollenstein (9409 ft.), the Realspitz (9996 ft.), the Riffler (10,625 ft.), and the Gefrorne Wandspitzen (10,789 ft.), and the magnificent Olperer (11,445 ft.), which is the culminating point. The neighbouring peak of the Fuss-stein (10,852 ft.) is separated from the Olperer only by a narrow gap. The largest glaciers of this group lie round about the Olperer; they are, on the north, the Gefrorne Wand Ferner, on the west the Wildlahner Ferner, and on the east the Lower Schramma Ferner. The broad depression of the Alpeiner Scharte (9709 ft.) then follows, over which a footpath leads from the Zamser Valley into the Valser Valley. The Schrammacher Spitz (11,186 ft.), which is the next in order to the south-west, is the most elegantly formed peak in the whole of the Zillerthal Alps. Next come the two Sägewandspitzen (the eastern 10,659 ft., the western 10,867 ft.), and then the Hohe Wand (10,779 ft.), wild, jagged horns of rock, from which the Stampfl Ferner descends nearly to the Pfitscher Joch (7316 ft.). This joch connects the Pfitscher Valley with the Valser Valley. The Kraxentrag (9824 ft.) stands on the further side of the Pfitscher Joch; it stands on a huge base, affords a magnificent view, and contains the last glacier in the main crest of the Tuxer Group. The Dornberg or Wolfendorn (9191 ft.), further to the south-west, also enjoys a reputation for its exceptionally fine view, and the same may be said of the Hühnerspiel or Amthorspitze (9006 ft.), above Gossensass.

The branches from the main crest of the Tuxer Alps lie altogether on the northern side of it, and cover the broad space which extends northward as far as the Inn, eastward to the Ziller, and westward to the valley of the Wipp. They are all connected with the main crest of the Olperer; the Schmirner or Tuxer Joch (7662 ft.), over which a bridle-path leads from the Tuxer Valley into the Schmirner and Wipp valleys, lies near this knot. As seen from a high point outside the district, it presents the appearance of a high plateau-like mass, though cut up by numerous deep channels, green, rich in pastures, and most favourable to the dairy industry, and available for traffic almost throughout, being, however, but rarely overshadowed by higher peaks, is, on the whole, somewhat monotonous. The Geierspitz (9500 ft.) is an important knot within this district, lying at the origin of the valleys of the Schmirn, Navis, Watten, and Jomsberg; four large crests unite in it, the Schmirner Kamm (to the south), the Schafleiten Kamm (to the south-west), the Glungezer Kamm (to the north-west), and the Hilpold Kamm (to the north). The Schmirner Kamm culminates in the Kaserer (10,034 ft.), which rises at the back of the Kaserer Valley, and the Schafleiten Kamm in the Schafleitenberg (8535 ft.), between the Schmirn and the Navis. The winding Glungezer Kamm extends from the Geierspitz over the Sonnenspitz (8439 ft.), the Gramarterspitz (8356 ft.), the Rosenjoch (9129 ft.), the Kreuzjoch (9177 ft.), which is the culminating point, and the Glungezer (8777 ft.) at Hall, to the Patscherkofel (7262 ft.), at Innsbruck; the beautiful Lanser Köpfe (3099 ft.) in the Innsbruck secondary range, also belongs to it. A northern collateral crest, the Haneburger Kamm, containing the Seekarspitz (9280 ft.), joins it in enclosing the Volderer Valley.

The Hilpold Kamm attains it greatest elevation in the Kalkwand (9243 ft.). The Rastkogel Kamm breaks off from this towards the east, culminates in the Rastkogel (8860 ft.), and

ends at the bend of the Ziller. The last-mentioned crest throws out the Gilferts Kamm, the highest point of which is the Dreispitz (8475 ft.), and ends at Schwaz with the Kellerjoch (7683 ft.).

(*b*) The ZILLERTHAL ALPS are bounded on the west by the Zillerthal from Zell upwards, by the Zemm Valley, the Zamser Valley, the Pfitscher Joch and the Pfitscher Valley; on the south by the Eisak from the mouth of the Pfitscherbach to Brixen, and by the Rienz to Bruneck; on the east by the Ahren Valley, the Birnlücke, and the Krimmler Valley; on the north by the Upper Salzach, the Gerlos Pass, and the Gerlos Valley. The main crest of the Zillerthal begins at the Birnlücke, and, like the Tuxer main crest, extends thence to the south-west, ending with the Trenser Joch above Trens, at Sterzing. It is thirty-eight miles long, and has an average height of 9513 feet. The first part, amounting to a third, sinks with unusual steepness into the Ahren Valley; in the higher pastures it is bare and jagged, being covered only here and there with ice; the peaks are rugged and steep, and are closely surrounded by sharp grats and numberless rocky points, making them apparently unapproachable. The most important peaks are the Rauch Kofel (10,654 ft.), the Napfspitz (10,337 ft.), and the Kielbachspitz (10,143 ft.). The central part (a third) of the main crest contains the highest elevations; the ice coating of the range is continuous and spreads for about four miles over both slopes, sending its glaciers down into the valleys: in consequence of the steepness of the southern slope, the ice-fields on the northern side are much more extensive. The Frankenbach Glacier and the Trippach Glacier slope down southwards, and the beautiful Floiten Glacier northwards from the Löffelspitze (10,859 ft.). Beyond this comes the double peak of the Floitenspitze (10,464 ft.), followed by the Schwarzenstein (11,405 ft.), the five Hornspitzen (the highest 10,842 ft.), and the Thurnerkamp (10,215 ft.), the finest peak in the

Zillerthal crest. The Rossruckspitze (10,697 ft.) rises north-west of the latter, and west of it is the towering mass of the Mösele (11,416 ft.); the Ewis (10,406 ft.) and the Weisszinth (10,719 ft.) follow in a south-westerly direction.

The largest glaciers in the group lie on the northern side between the Schwarzenstein and the Ewis; they are the Schwarzenstein Ferner, the Horn Ferner, the Waxegg Ferner, the Furtschagel Ferner, and the Schlegleisen Ferner. The last of the three portions of the main ridge is far less important in height than the other two, and has little snow or ice. The steepest slope in this portion is that descending to the Pfitscher Valley on the northern side. The culminating peak is the Hohe Kreuzspitze (9943 ft.).

It will be evident from the difference of the two slopes of the main ridge, that the larger branches are to be found only on the southern side. They are the Mühlwalder ridge, between the Weissenbach and Mühlwalder valleys, containing the Pfaffennock (9887 ft.), the Grubach ridge, between the Mühlwalder and Pfunderer valleys, containing the Eidexberg (Hegedex, 8974 ft.), the Pfunderer ridge, between the Pfunderer Valley and the South Valser Valley, containing the Wurmaul (9887 ft.), and the Ritzeil ridge, between the Valser Valley and the Eisak Valley; the Valser or Spingeser Jöchl (6316 ft.) leads over the latter ridge by means of a bridle-path from Mauls on the Eisak to Mühlbach in the Rienz Valley. The collateral ridges of the Zillerthal main crest increase steadily in length from east to west, but in the last of the three parts they are altogether wanting. The most easterly of them is the wild Ziller ridge, between the Krimmler Ache Valley, the Gerlos Valley, and the Zillergrund; it is rich in glaciers and contains the Reichenspitz (10,806 ft.), which is its culminating point. The fine Ahorn ridge runs along the western side of the Zillergrund; this also has glaciers; it reaches its highest point in the Felsspitze (10,557 ft.), and ends on the north with the beautiful

peak of the Ahornspitze (9725 ft.), a most important point of view.

The Floiten ridge separates the Stillup Valley from the Floiten Valley, culminates in the Kleinen Löffler (10,533 ft.), and ends with the Tristenspitze (9078 ft.) at Ginzling (3259 ft.). The two ridges which bifurcate towards the north-west are much shorter; they are the Mörchen ridge, between the Floiten Valley and the Zemmgrund, containing the Grossen Mörchenspitz (10,730 ft.), and the Greiner ridge, between the Zemmgrund and the Schlegeleisen Valley, containing the Grossen Greiner (10,353 ft.). The Hörpinger ridge, which proceeds from the Weisszinth, is still shorter, but contains the Hochfeiler (11,501 ft.), the culminating peak of the whole of the Zillerthal Alps; the Gross-Ingent (9560 ft.) is situated in a collateral branch.

There is less glacier formation in the Zillerthal Alps than in the Ötzthaler Alps and the Hohen Tauern. According to Von Sonklar the Zillerthal Alps proper have 110 glaciers, 5 of which are of primary importance, the Tuxer Alps 22, all of the second order. The lakes, the number of which Sonklar gives as 11, are all small; the largest is the Wildgerlossee, in the Wildgerlos Valley, at the foot of the Hohen Schaflkopf.

We must now turn to the valleys. The Zillerthal, the main valley of the whole group, may, from its size, cultivation, and population, be considered as the most important transverse valley in the Eastern Alps. Under the name of Zillerthal, it extends southward for $13\frac{1}{2}$ miles in a straight line from its mouth to Mairhofen (2095 ft.), charming the eye with its freshness and brightness. Fügen (1783 ft.), Zell (1878 ft.), the principal place, and Hippach (1944 ft.), are in this part of the valley. The Gerlos Valley opens eastward from Zell, and leads to the Gerlos Pass on the Pinzgauer Höhe (4717 ft.), over which the Salzach Valley is reached. The Ziller Valley divides into its four upper branches (Gründe) at Mairhofen.

The Zillergrund goes first east, then south-east; it is pleasant and cheerful in the lower part, rugged and gloomy in the upper. It is watered by the upper Ziller, which rises below the Heiligen Geist Jöchel east of the Rauchkofel. The Stillup Valley opens out west of the Zillergrund; it extends south-east, between the Ahornspitze and Tristenspitze, to the Zillerthal main ridge. The Zemm and Zamser Valley extends south and south-west from Mairhofen to the Pfitscher Joch, being the great main furrow of the range. The lower stage of it, as far as Ginzling, is called Dornauberg; from that place to the Breitlahner it bears the name Zemm Valley; and the upper part is the Zamser Valley. The valley is splendidly situated, and has several branches. The fourth valley, which opens out at Mairhofen, is the Tuxer Valley. Its lower half is a transverse valley extending east and west, the upper half a longitudinal valley extending south-west. The southern flanks, belonging to the main ridge of the Tuxer Alps, are extensively covered with ice, while those on the left rise in gentle slopes clothed with wood and grass, showing the wealth of pasture belonging to the valley. The Pfitscherthal is a longitudinal valley enclosed by the main ridges of the Tuxer and Zillerthal Alps. The highest stage, the Oberbergthal, is a wild, narrow mountain valley. The Pfitscherthal proper is divided into two parts by the steep stage called "Bei der Säge." The upper part, containing Kemathen (4792 ft.), charms the eye with the lovely verdure of the valley-bottom and the grandeur of the high mountains; the lower part, particularly in the neighbourhood of Wiesen (3096 ft.), possesses a milder climate, and consequently richer vegetation.

2. The HOHEN TAUERN extend westward to the Ahren Valley, the Birnlücke, and the Krimmler Achen Valley, northward to the Salzach Valley, as far as St. Johann, eastward to the Gross-Arl Valley, the Joch of the Arlthörl, and the Maltein Valley, southward to the valley of the Drave, the Toblacherfeld, and the upper valley of the Rienz, as far as Bruneck. It is the

The Gross Venediger and the Johannis Hut.

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most beautiful chain of high Alps in the eastern range; it is 83 miles long, and 28 miles broad, and covers an area of 2215 square miles. Its main ridge, which runs from west to east, contains the boundary between Salzburg on the north, and Tyrol and Carinthia on the south, so that the whole of its northern slope ($\frac{3}{9}$) belongs to Salzburg, the southern slope of the western portion ($\frac{4}{9}$) to Tyrol, and the eastern ($\frac{2}{9}$) to Carinthia. The massive Alp blocks of the Hohen Tauern are particularly rich in snow-fields and glaciers, which are here called *Keese* (Sonklar reckons 254), and in elevated valleys, which are not available for carriage traffic, and are called Tauern, a name connected, no doubt, with that of the Tauriskers (inhabitants of the Tauric Chersonese), who had settled here in olden times. Beautiful waterfalls abound here, and are among the chief attractions of the range, which in this respect is surpassed by no other mountain district of Europe, except, perhaps, the Scandinavian. The northern side of the range is the steeper, so that the numerous collateral valleys of the Salzach Valley—purely transverse valleys—are shorter than the branching collateral valleys of the Drave. A few of the southern groups are separated from the main chain by the latter valleys, thus causing a further subdivision of the range. These are as follows: (*a*) the Hohen Tauern proper, (*b*) the Antholzer Alps, (*c*) the Defferegger Alps, (*d*) the Schober Group, and (*e*) the Kreuzeck Group. The Tauern district, with a small exception, belongs to the primitive formations; a system of central masses, with almost the same direction as the orographical axis, is formed of granitic gneiss and gneiss, with which two more or less massive series of strata, belonging to the primitive schist formations, are connected on the north and south. The central masses referred to are those of the Venediger, the Hochnarr, and the Hochalpenspitz in the Hohen Tauern, and that of the Hochgall in the Antholz Group. A narrow zone of the trias formation is found on the northern side of the Hohen Tauern, having an east and west direction.

(*a*) The HOHEN TAUERN proper are bounded on the west by the Krimmler Achen Valley, the Birnlücke, and the Ahren Valley as far as Taufers, on the south by the Rein Valley, the Knutten Valley, the Klamml Joch, the Defferegggen Valley, the Ködnitz Valley, the Berger Thörl, the Leiterbach as far as Heiligenblut, and the valley of the Drave, from Möllbrücken to Spital, on the east by the Lieser Valley, the Maltein Valley, the Arlscharte, and the Great Arl Valley as far as St. Johann in the Pongau, on the north by the Salzach Valley as far as the mouth of the Krimmler Valley. They form, to a certain extent, a continuation of the Zillerthal Alps, and consist of a sharp main crest extending far into the snow region, and having short but massive spurs branching off from it, towards the longitudinal valley of the Salzach. The deepest depression of the main crest, the Velber Tauern (8333 ft.), which lies between the Velber and Tauern Valleys, separates it into two unequal parts, the western part being considerably shorter than the eastern. The peak of the Tauernkogel (9780 ft.) rises close to the Velber Tauern in the western part. From this point the crest leads first west, then south-west to the great Venediger Group, with its glacier masses, the Prettauer Keese, the Schlatten Keese, and the Obersulzbach Keese, and its fine culminating peak, the Sulzbacher or Gross-Venediger (12,047 ft.), with its splendid spreading snowfields. This peak is one of the least difficult to ascend in the whole of the Alps. The path to its summit is troublesome, it is true, but free from danger. The view from the summit over the distant mountains is truly magnificent. The Klein-Venediger (11,412 ft.), rises to the north-east, and the Aderspitze (11,492 ft.) to the south-east of it. The main crest runs south-west, over the Grosse Geigerspitze (10,996 ft.), the Heiligen Geist-Keeskogel (10,700 ft.), and the Simony Spitze (11,416 ft.), to the Dreiherrenspitze (11,492 ft.), on which the boundaries of three rulers (*drei Herrn*) formerly met; namely those of Tyrol, Salzburg, and Carinthia.

The Ziller Plateau and the Umbalthörl.

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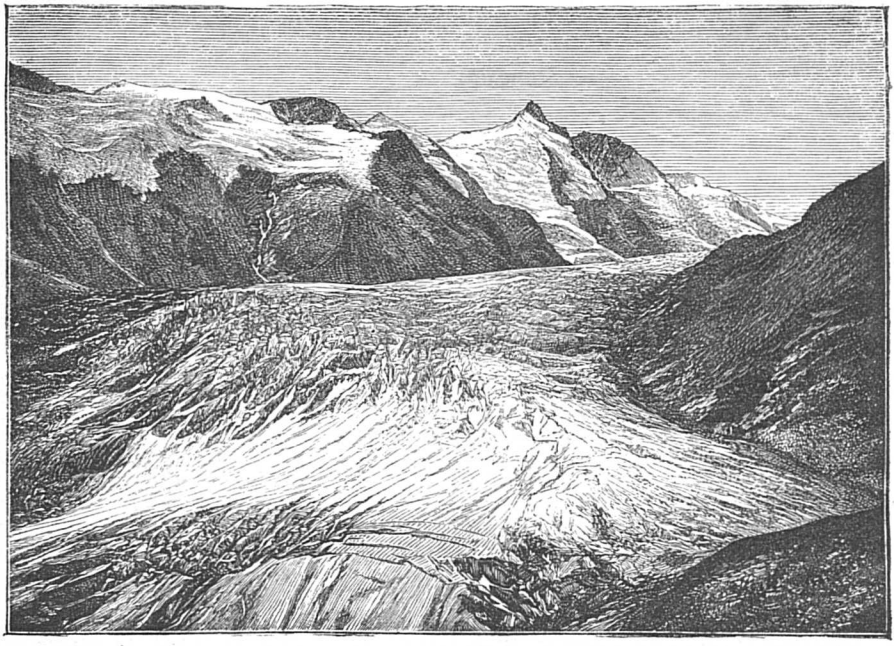
It has a beautiful view which is, however, obstructed to the north-east, by the Gross-Venediger. The Prettauerspitze (9686 ft.), stands north-west of the Dreiherrenspitze, and close to the Birnlücke, but the main crest continues in a south-westerly direction over the Rosshuf (11,482 ft.), the Hinteres Umbalthörl (9269 ft.), and Vorderes Umbalthörl (9851 ft.), the Eierspitze (10,463 ft.), and Virgljoch (10,812 ft.), to the huge Rödtspitze (11,456 ft.), and in its further course over the Löffelspitze (10,031 ft.), and Grossen Etschen (10,074 ft.), to the Affenthalspitze (10,100 ft.), and is up to this point everywhere rich in glaciers. The crest then sinks below the snow region, but rises again in the extreme south-west, with the peaks of the Hirbanock (9851 ft.), the Dürreck (10,324 ft.), and the Grosser Mostnock (10,034 ft.).

The collateral crests which stretch out westward from the main crest are all transversal, that is to say, their direction with regard to the main crest is normal. They present some glacier formation. A few transversal crests also run out on the southern side, such as the Eicham Grat, which proceeds from the Gross Venediger and contains the Hennenkopf (11,702 ft.), and the beautiful horn of the Eicham (11,051 ft.), from which the crest of the Wildenkamm, with the peak of the Wildenkogel (9897 ft.), runs out towards the south-east, while the longer crest, the Virgenkamm, between the Virgen and Defferegggen Valleys, has a more diagonal direction. In the latter crest are the peaks of the Musspitz (10,170 ft.) and the Lasörling (10,146 ft.). The highest parts of these crests also possess glaciers.

The Hochgasser (9224 ft.), near the Velber Tauern, forms the western corner of the eastern main crest of the Hohen Tauern, and the Kolben (8869 ft.), near the Arlscharte, forms the eastern corner. The main crest makes so many curves that it is only the mean direction which is east and west. The block-like branches which occur here, divide themselves, in consequence, into three gneiss masses, that of the Glockner to the

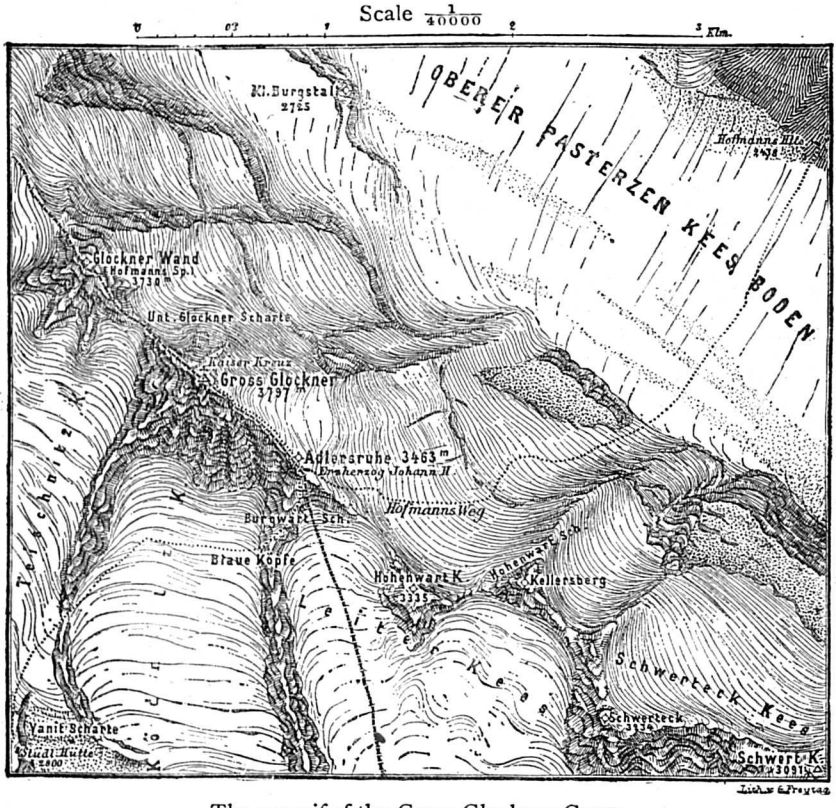
west, the Hochnarr and Scharreck in the middle, and that of the Ankogel and Hochalpenspitz to the east, the three being separated from each other by the saddles at the Hochthor, and at the Malnitzer Tauern. A smaller glacier-covered group, the Granatkogel Group, forms the passage from the Velber Tauern to the Glockner *massif*, as far as the Kalser Tauern (8406 ft.). This group culminates in the Granatenspitz (10,014 ft.), and in



The Gross Glockner, and the Pasterzer Glacier from the Elizabeth Ruhe.

the Rothen Kalser Tauernspitz (10,501 ft.). The Glockner Group, between the Kalser Tauern and the Hochthor (8436 ft.), begins to the west with the Hohen Kasten (10,418 ft.), which is followed eastward by the Eiskögele (11,280 ft.) and Schneewinkelkopf (11,192 ft.). The chain then splits up. The principal chain takes a sudden bend to the north over the Untere Ödenwinkelscharte (10,421 feet) and the Johannisberg (11,399 ft.), to the Hohen Riffel (10,957 ft.), when it again takes a south-easterly direction, containing, in this part, the peaks of

the Vorder Bärenkopf (10,670 ft.) and Mittler Bärenkopf (11,040 ft.), the Breitkopf (10,311 ft.), and south of the Fuscherkarscharte (9454 ft.), the Fuscherkarkopf (10,895 ft.); the southern collateral chain follows a south-easterly direction from the beginning, and mounts over the sharp and lofty Romariswandkopf (11,554 ft.) to the Gross Glockner. Both chains en-




The *massif* of the Gross Glockner Group.

close an oval, which is encircled by lofty peaks of ice. It is filled up by one of the largest and most regular glaciers in the Alps, the Pasterze, which descends from its huge snowfield in two falls. The Glockner rises from it 4590 feet, with sides which appear to be perpendicular; a view of overpowering sublimity is procured from it, and especially from the Franz Josefshöhe (7892 ft.), a celebrated spot on the opposite side of the glacier.

The Gross Glockner (12,455 ft.), which is the highest mountain in the Eastern Alps, is formed of chlorite-schist. It consists of two peaks, the Klein Glockner and the Gross Glockner, which are connected by the narrow ridge of a pass. The peak itself, when free from snow, as it is in the warmest part of the summer, is so narrow that there is scarcely room for six persons on it; it descends precipitously on the east, 4590 feet, to the Pasterze, as already stated, and almost as precipitously on the south, 3608 feet, to the Ködnitz Glacier. It descends on the north in jagged, inaccessible precipices to the Glocknerwand, while on the south a steep grat slopes down between the Ködnitz Glacier and the Teischnitz Glacier. In the year 1882 an iron cross, nearly six feet high, was erected on the summit by the Austrian Alpine Club. From the time when it was first ascended in 1799 to 1861, Heiligenblut, in the valley of the Möll, was the starting-point for the ascent of the Glockner, but after the latter year the Tyrolean village of Kals was considered the best point of departure. In more recent times still, some bold climbers have found a way direct to the Gross Glockner which leaves out altogether the Klein Glöckner, and the "Scharte," the most dangerous part; another way from the Pasterze side has also been discovered. The view from the Gross Glockner is magnificent, far surpassing that from the Ortler in the variety of objects it commands.

The Hohen Riffel, mentioned above, has the Thorspitze (10,476 ft.) for a near neighbour; east of the Vorderen Bärenkopf are the Grosse Bärenkopf (11,169 ft.), and the Kleine Bärenkopf (11,009 ft.), and south-east of the latter is the Hohe Dock (10,691 ft.). North of the Kleine Bärenkopf is the Glockerin (11,219 ft.), from which the Grosse Wiesbachhorn (11,733 ft.) is separated on the north-east by the Wiesbachthörl (10,576 ft.). This elegantly peaked horn rivals the Gross Glockner in beauty of form as well as in the view it affords. The chain which branches off northward from this, between the Kapruner and

Fuscher Valleys, culminates in the Hoch Tenn (11,051 ft.). Another collateral chain, which runs northward between the Kapruner and Stubach Valleys, contains the Kleinen Eiser (9516 ft.), and the Grossen Eiser (10,510 ft.), north of the Kaprunerthörl (8797 ft.), and on a line with these, the splendid pyramid of the Kitzsteinhorn (10,476 ft.). Another ridge is that of the Kalsergrat, which proceeds southward from the Granatkogel Group, between the Isel and Tauern Valleys on the west, the Kalser and Dorfer Valleys on the east; this also has glaciers, the Rolf Ferner (10,664 ft.) being the highest point. The little group of the Bärenkogel (9890 ft.) is separated from the Glockner mass on the east by the Untere Pfandlscharte (8751 ft.); south of it the Hochthor, or Heiligenbluter Tauern (8436 ft.), leads from the Fuscher Valley to Heiligenblut in the Möll Valley.

A low ridge leads from the Hochthor to the mass of the Hochnarr and Scharreck or the Goldberg Group, which stretches south-east as far as the Malnitzer Tauern. Though lower than the Glockner Group it is well furnished with glaciers, and culminates in the Hochnarr or Hohenaar (10,670 ft.). This is followed in a south-westerly direction by the Goldzechhörndl (9677 ft.), the Hintere Sonnblick (10,180 ft.), the Goldbergspitze (10,064 ft.), and the Tramerkopf (9640 ft.); north-east of the latter are the Herzog Ernst (9620 ft.) and the Scharreck (10,392 ft.). This group is famous for its former wealth of precious metals. Gold occurs scattered through the quartz veins, which appear on the northern side of the main ridge at a height of 7200 feet to 8500 feet. In the sixteenth century the yield was so great that the Gastein and Rauris Works had a world-wide reputation, but the depreciation in the value of gold in later years has almost destroyed the profit arising from the works. There are mines in three places. The mine of Kolm Saigurn (5277 ft.), below the Sonnblick, on which a meteorological station has now been erected, is a Rauris gold-mine,

from which an extremely steep ropeway leads to the engine-house (7141 ft.), lying much higher. The second mine is in the Gastein Radhausberg (8780 ft.). The mining work in the Carinthian Valley of the Fleiss is now quite abandoned; no other stream in Europe has been used for traffic at so high an altitude as this, the waters of the Goldzech or Zirm Lake (8194 ft.) having served for the transport of the ore from the gold-mines.

The Malnitzer or Nassfelder Tauern (7917 ft.), over which a bridle-path leads from the Gastein Valley into the Malnitz Valley, separates the Hochnarr Group from the mass of the Ankogel and the Hochalpenspitze. From this point the main crest at first becomes lower, passing over the Gamskarlspitz to the Hohen Tauern, and the Luggauerscharte (6376 ft.), which unite the Anlauf Valley and the Gastein Valley with the See Valley and the Malnitz Valley. The crest of the Ankogel Group stretches north-west and south-east. The Ankogel (10,670 ft.) rises about the middle of it, entirely covered with snow; it consists of a higher and a lower point, the depression between them being filled with glacier ice. The view of the high mountains, both distant and near at hand, is magnificent, being the more beautiful in consequence of all the groups appearing from this point, to be isolated, the neighbouring peak, however, the Hochalmspitze (11,006 ft.), covers one of them. From the latter point a transverse joch goes south-west, joining it to the lower extension of the main crest. This high chain, beginning with the Säuleck, extends south-east between the lower Möll Valley and the Maltein Valley, and is entirely devoid of glaciers. The peak of the Reisseck (9709 ft.) in this chain may be mentioned on account of its fine view.

Transversal collateral chains also run out northward from the eastern main crest of the Tauern, enclosing parallel transverse valleys. The streams of these valleys are all called Achen, and flow into the Salzach. The valleys proceeding from west to east, including the western part of the Hohen

Tauern are as follows: the Krimmler Achenthal, the Ober and Unter Sulzbachthal, the Habachthal, the Hollersbachthal, the Velberthal, from which the Ammerthal branches off to the south-east, the Stubachthal, the Kaprunerthal, the Fusch, Rauris, and Gastein Valleys, and the Gross-Arl Valley. The Seiten-winkel Valley branches off south-west from the Rauris Valley. The Gastein Valley, which is remarkable in many ways, is the largest of these Achen Valleys; it is nearly forty miles long from Lend in the Lower Pinzgau, to the foot of the Malnitzer Tauern. Like the Ziller Valley, it forms a trunk nearly twenty miles long from its mouth up to Hofgastein, its crown branching off to the Valley of the Tauern Chain, which breaks up towards the south; first, on the right the Anger Valley, on the left the Kötschacher Valley, which ascends to the Tauern chain on the borders of Carinthia, the main branch continuing past the bathing-place to Bockstein, where it bifurcates; left, through the Anlauf Valley to the Ankogel and Hohen Tauern; right, through the Nassfeld to the Malnitzer Tauern; these two branches are separated by the Radhausberg. The character of the collateral valleys of the Salzach in the Gastein Valley is especially beautiful, and may be taken as typical of all the Achen Valleys. The valley plain lying between the slopes, is called in this neighbourhood the "Thalboden" or valley-bottom. The upper or more remote "Thalboden" is the Nassfeld, a beautiful broad cauldron 5245 feet above the sea; the Ache, which has collected its waters in this part of the valley, descends as the Bären and Kessel Falls into the Böcksteiner Thalboden (3771 ft.). After a peaceful course of three or four miles, it reaches a precipice 688 feet high, over which it leaps in two beautiful cascades, of 196 feet and 295 feet respectively, into the Thalboden of Hofgastein (2788 ft.). The latter extends to the Klamm, or defile (the Klammstein Pass, 2399 ft.), through which the Ache dashes, first in wild torrents and finally with a bold leap of 230 feet, into the Salzach at

Lend (2070 ft.). The entire valley is called the Gastein; but there is no special place of this name. The first place, beginning at the lower part, is Dorf or Dorfgastein, the second, the principal place, Hof or Hofgastein (2849 ft.), the third, the

The Three Krimmler Falls.

bathing-place, Wildbad in der Gastein (3354 ft.), celebrated for its warm springs of eighteen different temperatures from 26° to 5° Cent.

The other Achen Valleys, like the Gastein, have narrow passages leading from the Salzachthal, the so-called "Klamms."

The Liechtenstein Klamm, at the entrance to the Gross-Arl Valley, and the Kitzloch Klamm of the Rauris Valley, are the most celebrated, on account of their wild beauty; both have in recent times been made accessible, the bold undertaking of making a path through them having been accomplished.

The Krimmlerthal, the most westerly of the Achen Valleys, owes its renown to the three magnificent waterfalls, in which the Krimmler Ache descends to the lowest stage of the valley. The Krimmler falls are the most important in the Eastern Alps, being altogether about 1475 feet high. The lowest fall is the wildest, and its raging waters and rainbow-tinted spray form a picture of indescribable beauty. The upper fall is the largest, descending from a wall of gneiss 1035 feet high, with a roar like thunder, into the abyss below.

We must now turn to the groups lying south of the Hohen Tauern, and begin with,

(*b*) The ANTOHLZER GROUP which is enclosed by the Achen Valley, the Rein and Knutten Valley, the Klamml Joch, the Upper Deffereggen Valley, the Stalleralpe, the Stalleralp Sattel, the Antholzer Valley, and the Rienz. It is small, but is remarkable for its height and its great extent of glacier. The main crest has first a north and south, and then an east and west direction. In the first section the Gelenkhorn (10,852 ft.), and Lengstein (10,615 ft.), may be mentioned. The Hochgall (11,290 ft.) stands at the bend of the crest; it is the highest peak of this group, and has a fine view; the Wildgall (10,724 ft.) stands near it to the south-west, and the Riesernock (9614 ft.) to the north. The great Lengstein Glacier spreads between this latter mountain, the Hochgall and the Lengstein, while the three Rieser Ferner fill the space south-west of the Riesernoch, as far as the Wild-gall and the Schnebgenock or Ruthnerhorn (7840 ft.), to the south. From these glaciers the whole group is now usually called the Rieserferner group. A path leads over the Rieser-

ferner from the Rein Valley to the Antholzer Scharte (8121 ft.) and into the Antholzer Valley. The most westerly part of the main crest culminates in the Rauchkofel (10,228 ft.), and the Fensterkofel (10,428 ft.). A bridle-path leads over the Klamml Joch (7602 ft.), out of the Rein and Knutten Valley, past the Klamml Lake (7367 ft.), into the Affenthal, that is, the upper part of the Deffereggen Valley. The Stalleralp Saddle (6736 ft.) connects the Valley of the Stalleralp, which opens into the Deffereggen Valley, with the Antholzer Valley; the bridle-path leads past the Staller Lake (6596 ft.) and the Antholzer Lake (5392 ft.), which is larger. The Ahren Valley or Tauferer Valley, which bounds the group on the west, and opens into the Puster Valley at Bruneck (2705 ft.), extends for nearly fifty miles; first, as far as Luttach (3139 ft.), in a northerly direction, then in a north-easterly direction, between the Zillerthal Ferner and the Rieser Ferner to the Tauern chain. The middle part of the valley, from Luttach to St. Peter (3936 ft.), is called the Ahren Valley, and the upper end of the valley, the Prettau. Taufers (2833 ft), the principal place, situated at the foot of an old castle, is the most beautiful spot in the valley.

(*c*) The DEFFEREGGEN MOUNTAINS are bounded by the Deffereggen Valley, the Isel Valley as far as Lienz, the Valley of the Drave, the Toblacher Feld, the Upper Valley of the Rienz from Toblach to the mouth of the Antholzer Valley, the Antholzer Valley, the Stalleralp Saddle, and the Stalleralp. It is a massive range, reaching nearly to the snow region, with a complicated crooked crest-line, sloping down to the surrounding valleys, with rugged and precipitous flanks. The main crest extends in an east and west direction parallel with the Deffereggen Valley, and culminates in the Weiss-spitz (9709 ft.). A bridle-path west of that mountain leads over the Villgraten Joch (8699 ft.) from the Deffereggen Valley, into the Villgraten Valley. The mountain next the Weis-spitz on the east

is the Grossdeggenhorn (9654 ft.), which is succeeded by the Wagensteinspitz (9542 ft.), the Hochalm (9167 ft.), and the Regenspitz (9477 ft.). The Abfalternkamm, containing the Gölbner (9643 ft.), turns southward from the Regenspitz. The Gsieser Kamm extends south-west as far as the Drave, west of the Gsieser Valley, and is separated from the main crest by the Gsieser Joch, or Gsieser Thörl. It contains the Grossen Pfannhorn (9246 ft.), the Kerlskogel (9274 ft.), and the Rothwandspitze (9230 ft.). The Deffereggen Valley is on the whole monotonous, but the end towards the Rieserferner group is well worth a visit. The valley is the seat of the carpet manufacture, high German and foreign languages are therefore frequently found here, as well as the town fashions. The principal place is St. Jacob (4522 ft.).

(*d*) The SCHOBER GROUP extends on the north to the Ködnitz Valley, the Berger Thörl, and the Leiter Valley, on the east to the Möll Valley, and the road over the Iselsberg, on the south to the Valley of the Drave from Dölsach to Lienz, on the west to the Isel Valley and the Kalser Valley. The highest peak of this very simple group reaches into the snow region, and also possesses glaciers. The main crest stretches from the mouth of the Kalserbach, over the Kreuzspitze (9623 ft.), the Hochschober (10,838 ft.), the Glödis (10,520 ft.), the Little Gössnitzkopf (10,212 ft.), the Flammenkopf (10,277 ft.), and the Seekopf (10,083 ft.), to the Kreuzkopf (8162 ft.), at Heiligenblut. A collateral crest, containing the Wandschusswand (10,287 ft.), and the Bösen Weibele (10,314 ft.), goes out northward from the Little Gössnitzkopf, to the Berger Thörl or Kalser Thörl (8836 ft.), over which a bridle-path leads from the Möll Valley into the Kalser Valley. A second collateral crest stretches from the Flammenkopf towards the south-east; it culminates in the Kruckelkopf or Weissenbachspitz (10,412 ft.), which, however, is exceeded in height by the Petzeck in an easterly branch. It ends at the cart-road over the

Iselsberg (3949 ft.), which connects Winklern in the Möll Valley with Dölsach on the Drave. The lower part of the Isel Valley, which opens at Lienz (2186 ft.), is monotonous. The sides of the valley do not approach each other till In der Huben (2571 ft.) is passed, where the Deffereggen Valley opens on the one side, and the Kalser Valley on the other. Then the valley widens out into a beautiful cauldron, in which the principal place, Windisch Matrei (3190 ft.), stands. Here the Isel Valley turns to the west and takes the name of the Virgen Valley, from the place Virgen (3902 ft.); Pregaten (4273 ft.), lies farther up; the highest part of the Isel Valley is the Umbal, which is well worth seeing; it leads into the Vorderen Umbalthörl, and the splendid Umbal glacier descends into it. The northern extension of the lower Isel Valley, from Windisch Matrei, is the Tauernthal, the upper end of which is connected with the Velber Valley, by means of the Velber Tauern (8333 ft.), in the Hoch Tauern main ridge. The Gschlöss Valley branches off to the west. The Kalser Valley, stretching away northward to the Glockner group, affords a fine view, from a point quite near its entrance, of the Gross Glockner, with the Glocknerwand, the Ködnitzkees and the Teischnitzkees. The pleasant village of Kals (4332 ft.), as already mentioned, is now the principal starting-point for the ascent of the Glockner.

(*e*) The Kreuzeck Group is bounded on the west by the road over the Iselberg, on the north by the Möll, from Winklern to the mouth of the river, on the south by the Drave, from Dölsach to Sachsenburg. Though entirely below the snow-line, it is remarkable for its precipitous outlines. The Kreuzeck (8846 ft.), rises in the middle of the group, having the Hoch Kreuz (8869 ft.) on the south-west; north-west of the latter is the Grindelkopf (8702 ft.); east of the Kreuzeck are the Stampfel (8496 ft.), the Schraneck (8341 ft.), and the Grosse Grakopf (8362 ft.). North of the Kreuzeck the saddle of the Wöllathörl (8069 ft.) separates the main ridge from the Polinik ridge,

which contains the Strieden Kopf (9033 ft.), and the Polinik (9119 ft.).

The Valley of the Möll is the longest and most beautiful of all the Tauern Valleys. From its upper end to Winkeln it is a transverse valley, having a north and south direction, while its lower half is a longitudinal valley, running first north-east and then south-east. The Valley of the Möll, a river which emerges from the glaciers of the Glockner, is a true primitive mountain valley. All the slopes are green, being for the most part well wooded, and having amongst the green, brown groups of houses, cornfields, and meadows. The landscape becomes finer and more severe as we ascend. As the mountains approach each other, and the valley bottom consequently contracts, the brown tone of the rocks predominates. In the highest habitable stage of the valley, the forest forms only a narrow border down below, and the silvery ice encloses the shoulders and joints of the mountains. One stage higher and we stand on the dazzling floor of ice itself, pinnacles, walls, and foot of the mountains are covered in brilliant winter clothing, and the black primitive schist only here and there breaks through the gleaming mantle. Below Heiligenblut the stream forms the cataract of the Möll, and the splendid Zlapfall (260 feet high). The tributary streams are also rich in waterfalls; the finest are the Zirknitz Fall (200 feet high) at Döllach, the Jungfernsprung (426 feet high), below Heiligenblut, the Gössnitz Fall, the Kessel Fall, and the Leiterbach Fall (212 feet high), above Heiligenblut. Landslips and torrents have worked terrible havoc in the valley. The best known places in the Möll Valley are Ober-Vellach (2249 ft.), at the opening of the Mallnitz Valley, Winklern (2811 ft.), Döllach (3370 ft.), at the mouth of the Gross Zirknitz Valley, and especially Heiligenblut (4605 ft.), the highest village in Carinthia, and the former starting-place for the ascent of the Glockner. The valley is remarkably rich in little mountain lakes, from which nearly all the tributaries of the

Möll originate. These lakes lie at a height of over 5250 feet, and are sometimes surrounded by grassy pastures, but more often by loose rubbish, and are frozen over for the greater part of the year. The little Fleissbach, the two Zirknitzbäche, and the Wurtenbach, which flows through the Fragant Valley, have their origin in such lakes as these. The Tauern ridge from the Hochnarr to the Mallnitz forms a lake district. The Oschenig Lake (7623 ft.), is situated farthest to the south-east, and north-west of it are the Feldsee, the Weissensee, and the Schwarzsee, and still higher the two Zirknitz lakes, and highest of all the Goldzech, or Zirmsee (8194 ft.), which has been already mentioned. A second lake district is situated in the Group between the Mallnitz, Möll, Lieser, and Mala Valleys, on the Sonnblick, Reissek, and the Hohen Leier (8108 ft.).

3. Between the Arlscharte and the source of the Mur, the central zone of the Eastern Alps divides into two branches, separated from one another by the Mur. The north-eastern branch bears the name of the NIEDERE TAUERN, as far as the pass between the Palten Valley (to the Enns) and the Liesing Valley (to the Mur). The range running north-east, on the further side of this depression does not belong to the central zone of primitive mountains, which breaks off much sooner here than in the south, but is a transition range, which may be more properly reckoned with the northern limestone Alps. The Niedere Tauern are bounded on the west by the Great Arl Valley, on the north by the Little Arl Valley, the Wagreiner Höhe and the Enns Valley as far as Selzthal, on the south by the Mur Valley from St. Michael to Moritzen near the source of the Mur, by the Moritzen Valley and the Schöderalp. It covers an area of 1687 square miles, the western portion belonging to Salzburg, and the eastern to Styria. Being considerably lower than the Hohen Tauern it has neither snow-fields nor glaciers, and does not present such sharply-defined crests as that range. Here also the passes are called Taern, but they are deep indentations of the

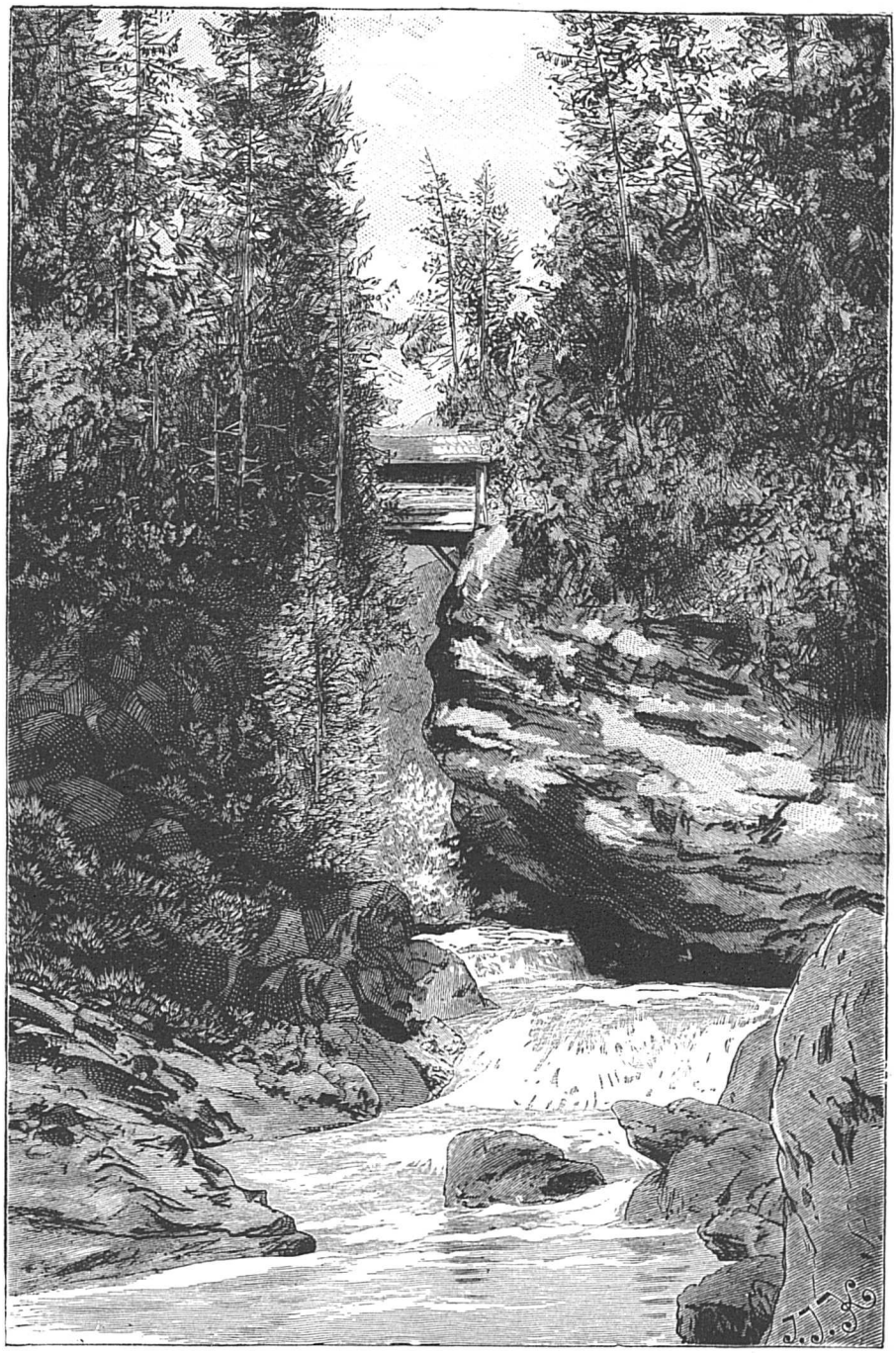
crest, lying as low down as the forest region. Sonklar gives four subdivisions: (*a*) The RADSTÄDTER TAUERN stretch eastward as far as the Valley of the little Sölk, to the Trattenscharte and the Lessach Valley as far as Tamsweg. They take their name from the Radstädter Tauern (5700 ft.), the pass which connects the Valleys of the Enns and Mur. The high road leads from Radstadt (2807 ft.), on the Enns, through the valley of the Tauernache with its wealth of waterfalls, up to the top of the pass where the Tauern House, a kind of hospice, stands, with a chapel and graveyard. In the Taurach Valley the road descends, going through the Valley pass of Tweng (4086 ft.), and passing Mauterndorf, reaches the little town of St. Michael (3502 ft.), on the Mur, then crossing the Katschberg Pass leads to Spital at the mouth of the Lieser. The highest peaks, proceeding from west to east, are, the Tappenkar (7187 ft.), east of Hofgastein, the Rothhorn (8168 ft.), the Mosermandl (9016 ft.), the Windsfeldspitz (8811 ft.), the Kreuzspitz (8725 ft.), and the Hochgolling or Hochgailing (9390 ft.), the culminating peak of the Niedere Tauern. The principal chain throws out, both north and south, a large number of collateral chains parallel with each other, which here and there rise to a considerable height, as in the case of the Hochwildstelle (9008 ft.) southeast of Schladming. The valleys between these collateral chains are especially extensive on the southern side of the main crest, and all radiate towards Tamsweg in the Upper Valley of the Mur. All the valleys here bear the suffix "Winkel," as in other places they have that of "Gründe," "Gräben," &c., thus we have Murwinkel, Zederhauswinkel, Lautschfeldwinkel, Weissbriach, winkel, Göriachwinkel. (*b*) The WÖLZER ALPS are bounded on the north by the Enns, west by the Valley of the Little Sölk, the Trattenscharte, and the Lessach Valley, south by the Mur, east by the valley of the Pölzbach from Judenburg to Möderbruck, the Bretsteinbach and the Gollingbach which flows into the Enns. In the principal chain are the peaks of the

Predigerstuhl (8349 ft.), the Döneck (7961 ft.), the Schoberspitz (7927 ft.), the Hohenwart (7725 ft.), and Breiteck. Between the Döneck and the Schoberspitz a bridle-path leads over the Sölkerscharte (5871 ft.) from the Great Sölk Valley into the Katsch Valley. The Greimberg (8097 ft.), which has a fine view, rises south of the Schoberspitz. In this section of the range also, the valleys on the southern side are longer than the collateral valleys of the Enns Valley. They are, the Ranten Valley, the Katsch Valley, the Wölz Valley, and the Bretstein-Pols Valley. The Great and Little Sölk Valleys, collateral valleys of the Ennsthal, surround the handsome block of the Knallstein (8525 ft.). The Preber (9204 ft.), a mica-schist mountain, is worth ascending for the sake of its splendid view. It stands south-west of the Predigerstuhl and above the Preber Lake (4896 ft.), the largest in the Lungau. (*c*) The Rottenmanner Tauern, between the Breitstein valley on the south, the Golling Valley on the west, the Enns Valley and the Palten Valley on the north, and the Tauern road from Trieben to Möderbruck on the east, contain in a short main crest the Hochschwung, the Neualpenhorn and the Great Bösenstein (8032 ft.). The Tauern road leads south-east from Liezen (2161 ft.) on the Enns to Rottenmann (2209 ft.), and Trieben (2322 ft.) in the Palten Valley, then ascends, in the valley of the Triebenbach, to the top of the pass (4139 ft.) where the Tauern House stands in a desolate tract, and then descends through the valley of the Pölsbach to Judenburg (2380 ft.), on the Mur. (*d*) The Seckauer Alps or Zinken Group are bounded on the west by the Rottenmann Tauern road from Trieben to Thalheim, on the south by the Mur from Thalheim to St. Michael, on the north by the Liesing Valley, the Walderhöhe, and the Palten Valley, as far as Trieben. They culminate in the Zinkenkogel (7865 ft.) with its magnificent panorama. The Crown Prince Rudolph railway follows the route of the old road, going through the Palten Valley, past the little Gaishorn Lake (2315 ft.),

over the Schober Saddle (1954 ft.), and through the Liesing Valley.

4. The primitve ALPS of CARINTHIA and STYRIA are bounded on the west by the Moritzen Valley, the Schöderalp, the Arlscharte, the Maltein and Lieser Valley, on the south by the Drave from Spital to St. Lorenz, on the north by the Mur as far as Bruck, and on the east by the Mur from Bruck to Graz, then by a line from Graz through Tobelbad (1147 ft.), Lannach, Stainz (1099 ft.), Deutschlandsberg (1220 ft.), Schwanberg (1412 ft.), Eibiswald (1186 ft.), Arnfels (1038 ft.), Leutschach (1153 ft.), and St. Lorenz (1084 ft.), along which they pass into the Styrian Niederalps and the Windischen Bühel. They include a district of 3170 square miles, and belong in the south to Carinthia, in the north-west to Salzburg, in the north and east to Styria. This range has none of the regular chain formation of the Hohen and Niederen Tauern, but breaks up into broad masses with flat central summits, and with valleys radiating to every side, which are thickly populated, and are very fertile. Gneiss and mica-schist are the prevailing rocks. A more satisfactory idea of this extensive district, will be obtained by making a further subdivision, which may begin in the north-west with (*a*) the PÖLLAER ALPS, which are enclosed by the Upper Mur Valley, the Moritzen Valley, the Schöderalp, the Arlscharte, the Maltein Valley, the upper Lieser Valley, and the Katschberg Pass. Although circumscribed in area, they soar into the snow region, and even possess small glaciers. The main crest, which stretches north-east and south-west is connected at the Arlscharte with the Hohen Tauern; here the Marchkarkogel (9240 ft.) stands, followed on the south-east by the Hafnereck or Hafnerspitze (10,041 ft.), and then by the Sonnenblick (9923 ft.). The carriage-road over the Katschberg (Katzen Tauern 5383 ft.) connects St. Michael in the Mur Valley, with Spital in the valley of the Drave. (*b*) The STANG ALPS are bounded on the west by the Katschberg and the Lieser Valley, on the north by

the Mur Valley as far as Scheifling, on the east by the Perchauer Saddle, the Olsabach, the Metnitz and the Gurk, on the south by the Drave from Spital to the mouth of the Gurk. The whole district is below the snow-line. The Stang Alps consist chiefly of two chains extending north and south. In the western branch are the Pressingberg or Bergwurzeck (7757 ft.), then the Königstuhl (7646 ft.) and south-west of the latter the Roseneck (7983 ft.); the eastern chain culminates in the Eisenhut (8007 ft.). The two chains are separated from each other by the road, which leads southward from the Mur Valley, through the Predlitzgraben to the Turracher Saddle on the Turracher Lake (5782 ft.), and through the Seebach Valley to the Gurk. The Stang Alps become considerably lower between the Metnitz and Gurk Valleys farther to the east; the Mödringberg (5534 ft.), is the highest peak in this part of the range. The group of the Kuhalp in the north-east, between the Lassnitz, the Metnitz, the Mur, and the road over the Perchauer Saddle, also sinks considerably opposite the northern Stangalps; in the Kuhalp it rises to the height of 5852 feet, and in the Grebenzen to 6218 feet. Turning to the valleys of this district we find, within the zone of primitive rocks, large lakes, such as are not met with out of Carinthia. Unlike the other great lakes of the Alps, the Carinthian lakes lie in the longitudinal valleys. The largest of them, the Millstätter lake (1902 feet above the sea, 8½ square miles long, 908 feet deep) lies in the bosom of one of the Alp valleys running parallel to the valley of the Drave. A beautiful well-wooded range of mountains separates it from the latter on the south-west; the north-eastern shore, on which the town of Millstatt is beautifully situated, is softer and more closely cultivated. The Lieser, which carries off the waters of the lake, flows into the Drave at Spital (1817 ft.). The valley of this river penetrates the mountains as far north as the little town of Gmünd, (2399 ft.); it then forms a bow curving north-east, north, and north-west, as far as Hafnereck where the Lieser rises. From



Foot-bridge in the Malta Valley.

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Gmünd the beautiful Maltein or Malta Valley leads up, in a north-westerly direction, to the Ankogel. This valley is about forty miles long, and is rich in waterfalls, among which are the Fallbach Fall, the Göss Fall, the Schleier Fall, and the Melnik Fall. The most beautiful point in the valley is at a lovely little lake called the Blauen Tumpf. The Ossiach Lake (1599 feet above the sea, 10½ square miles in extent, 150 feet deep) lies in the valley of the Treffenbach or Seebach, which falls into the Drave below Villach. It has a solitary, somewhat melancholy aspect, not altogether picturesque. The small but lovely Afritzer Lake lies north-west of it on a tributary valley of the Afritzbach.

The most extensive stretch of valley within the Stangalps is that of the Gurk. This river flows out of the little Torer Lakes (5817 ft.), on the Torer Alp, south-east of Eisenhut, and winds so frequently that in its course it turns to every point of the compass. Gurk (2170 ft.) and Strassburg (2158 ft.) lie on its middle course. Below Strassburg it runs left to the Metnitz which also receives the Olsa flowing from the north. The old walled town of Friesach (2088 ft.), stands at this point. It was important in the middle ages from its trade in salt and iron, and from its situation on the great Italian high road. This road (a greater part of which is now followed closely by the main line of the Crown Prince Rudolph railway) leads through the Gurk, Metnitz, and Olsa Valleys, to the ravine "In der Klamm," and over the Perchauer or Neumarkter Saddle (3296 ft.), then to Scheifling (2577 ft.), in the Mur Valley, where it is joined by the roads over the Walder Höhe, and the Eisenerzer Tauern, and that to Leoben. The Gurk Valley widens out below Althofen (2009 ft.), into the Krappfeld, which is joined on the south-west, on the Glan, by the classic Saalfeld (Zollfeld or Sollfeld), where in Roman times a *Flavium solvense* must have lain, as well as *Virunum*. St. Veit (1557 ft.), the former capital of Carinthia, stands among numerous fortresses either whole or in ruins, at the point where the Glan, the most important affluent

of the Gurk, turns towards the Zollfeld. The present capital Klagenfurt (1462 ft.), stands further down the Glan; the town is nearly square, and has straight broad streets; it is near the Glanfurt, from which it takes its name. The Lend canal leads from the Glanfurt to the Wörther or Klagenfurter Lake (1438 feet above the sea, seventeen square miles in extent, 212 feet deep), which winds for several miles between pleasant banks. A charming view of the lake is obtained from the Castle of Maria Loretto, which stands on a peninsula at its eastern end; the beautiful Schlangen or Einsiedler Isle lies in this lake. The little circular lake, the Keutschachersee (1665 ft.), south of the Wörther Lake, differs both in form and position from the larger lakes.

(*c*) The JUDENBURGER or SANTHALER ALPS are bounded on the west by the Neumarkter Saddle, by the Olsabach, and by the Metnitz as far as Althofen; on the south by the road from Althofen to Mösel on the Görschitz, by the Löllinggraben, the Klipitzthörl and the Klipitzgraben; on the east by the Lavant downwards from Wolfsberg, then by the Obdacher Saddle and the Obdacher Valley; on the north by the Mur from Weisskirchen to Scheifling. They form a bold crest, extending north and south, contained within the lower region of the secondary Alps. The highest peaks are, the Wenzel Alp (7063 ft.), the Zirbitzkogel (7862 ft.), the Fuchskopf (7265 ft.), the Pressner Alp (6152 ft.), and the Hohenwart (5068 ft.). A carriage-road leads over the Klipitzthörl (5386 ft.) from Huttenberg (2514 feet), at the foot of the celebrated Carinthian Erzberg (ore mountain) to St. Leonard (2374 feet), on the Lavant. (*d*) The SAUALPE, between the road over the Klipitzthörl and the Valleys of the Gurk, the Lavant, and the Drave, lies due north and south, and culminates in the Great Saualpe (6825 ft.). The Gertrusk (6684 ft.) and the Forst Alpe or Kirchberger Alpe (6687 ft.), stand north of this mountain, and the Speikkogel (6227 ft.), and Little Saualpe (5600 ft.), south of it. The exquisite Lavant Valley, which opens into the Valley of the

Drave at Lavamünd (1128 ft.), is of considerable breadth as far as Wolfsberg (1510 ft.), but is narrower in the upper part, in which the health-resort Preblau (2598 ft.) is situated. A road leads out of it, northward over the Obdacher Saddle (3099 ft.), to Weisskirchen (2255 ft.), in the Valley of the Mur. (*e*) The BRUCKER ALPS or the Gleinalpen Kette extend from the Obdacher Saddle to the gap of the Mur at Bruck in a north-easterly direction. They are bounded on the south by the Teigitschbach, by the saddle over the Pack, and the Waldsteiner Graben, on the west by the upper Lavant, and the Obdacher Saddle, north by the Mur from Weisskirchen to Bruck, east by the same river from Bruck to Peggau; to the south-east they pass into the Styrian highlands, between the Mur and the Kainach. The south-western group is that of the Stubalpe, containing the Grössing or Grössenberg (7085 ft.), the Ameringkogel (7163 ft.), and the Speik Kogel (6536 ft.). A road leads south-east from Weisskirchen, on the Mur, over the Purker Höhe (3656 ft.), and the saddle called "Beim Gaberl" (5087 ft.), to Köflach. Next comes the Gleinalpe, containing the Speikkogel (6523 ft.), and then, to the north-east, the Brucker Hochalpe (5389 ft.). These two are separated from each other by the depression of the Diebsweg (3868 ft.), a beautiful pass between Leoben (1745 ft.) and Frohnleiten (1423 ft.). The Kainach Valley runs from the south-east far into the mountains. The busy little town of Voitsberg (1392 ft.) is situated in the upper part of it, and the market-town of Köflach at the mouth of the Sallabach; the latter is the centre of the brown-coal industry of this neighbourhood. (*f*) The KORALPEN Chain, or the Stainzer Alps, are separated from the Brucker Alps on the north, by the carriage-road over the Pack Saddle (the Vier Thore, 3823 ft.), which leads from the Valley of the Lavant, through the Waldsteiner Graben, into the Valley of the Teigitschbach and to Köflach. The Lavant Valley forms the western boundary, and the Drave downwards from Lavamund forms the southern

boundary. The group flattens down towards the east, and merges into the chain of mountains and hills between Kainach, Lassnitz, Sulm, and Pössnitz. In the middle of the chain, which stretches north and south, the Koralpe or Great Speikkogel (7023 ft.), rises, and north of it the Bärenthalkogel (6491 ft.), and south of it the Kleinalpe (5872 ft.). The chain which slopes steeply to the east of the Koralpe, between the valleys of the Black and White Sulm, is called the Schwanberger Alps, and contains the Waldschneck (5572 ft.). A carriage-road goes from Eibiswald (1186 ft.), in the Sagau Valley, to Mahrenberg (1216 ft.), on the Drave, passing over the Radelberg saddle (2196 ft.), and separating the Radelberg (3441 feet at the Kapunerkogel), which belongs to the molasse formation, from the Koralpe. The latter forms the most westerly part of the Possruck, that flat mollasse ridge entirely devoid of the Alpine characteristics, which extends between the Drave on the south, and the Pessnitz and Pössnitz Valleys on the north, as far as the Platsch, a pass road from the Mur Valley to Marburg (902 ft.), on the Drave. Its outermost spurs reach as far to the east of this road as Pettau (754 ft.), being in some parts no more than 1300 feet high, while the Possruck itself is more than double that height (Serschen 3164 ft., Kolarkogel 3214 ft., Jarzkogel 3167 ft.). North of the Possruck is the most favoured district of Styria, the Windischen Büheln; it is bounded on the west by the Sagau Valley, on the south by the Pessnitz, the Pössnitz, the Pettauer Feld, and the Drave, and on the north by the Valley of the Mur. The chain is composed of neogene marls, and sandstones; it reaches, in the western part only, to over 2000 feet (Kreuzberg 2076 ft.), then it approaches the east, sinks suddenly to less than 1600 feet, and finally to less than 1000 feet; it is one of the most delightful vine districts of Austria, forming a confused sea of hills, covered as far as the eye can reach with vineyards and orchards. The celebrated south Styrian wines, Luttenberger, Jerusalemer, &c., grow here, and it is the favourite summer-resort of Styria.

5. The STYRIAN NIDERALPS are bounded on the west and south by the Mur, on the north by the Mürz from Bruck to Mürzuschlag, the Fröschnitz Valley, the Semmering Pass, the Weissenbach from Schottwien to Gloggnitz, the Schwarza from that place to its junction with the Pitten, then by a line through Walpersbach, Hochwolkersdorf (2048 ft.), Schwarzenbach (1259 ft.), Kobersdorf, St. Martin and Mannersdorf on the Rabnitz; on the east, between the valleys of the Rabnitz, Pinka, Lafnitz, Raab and Mur, they merge into the Styrian and Hungarian Highlands. They cover an area of 1497 square miles, of which the greater part belongs to Styria; in the north-east only they reach into Lower Austria and Hungary. The tertiary mountains prevail here as well as in the range west of the Mur, as far as the Koralpe. The Devonian formation appears to a considerable extent in the north, and is succeeded still farther to the north by a tract of the northern schist zone. It is only in the north-east that a few peaks rise above the mountain region; with the exception of these we find everywhere gentle undulations, generally with flattened summits. The western portion, extending as far as the lower Fröschnitz, the Steinbach Graben, the Reitenauer Alpe, and the Little Pfaffenbach, as far as Rettenegg on the north, and as far as the Feistritz on the east, is known as the Fischbacher, Raabthaler or Cetic Alps. The valleys run in three directions; in the north the collateral valleys of the Mürz and the Mur, as well as the Stainzer Valley and the Breitenau extend east and west; in the middle part the valleys of the Ilz, Raab, and Rabnitz, run parallel to each other towards the south-east; but in the south, the collateral valleys of the Lower Mur, the valleys of the Stiefing, Schwarzenau, Sass, and Gnas, run north and south, the valleys indicating the direction of the separate chains of mountains. The highest is the chain of the Reitenauer Alps running along the Mürz to the south-west; it begins in the north-east with the Pretulalpe (5431 ft.), which is followed by the Teufelstein (4915 ft.), the Hochalpe (5189 ft.), and the Hochlantsch (5646 ft.), the latter being the culminating peak

of the Fischbacher Alps. South-west of this, the Röthelstein (4046 ft.) stands, containing the Drachenhöhle (dragon's cave), at Mixnitz in the Mur Valley, and to the east the Plankogel (5024 ft.), and between these two, the Osser (5080 ft.), in which the Raab rises, afterwards breaking its way through the Raaber Klamm. Farther to the south the Schöckel (4743 ft.) stands, having at its south-east foot the health-resort Radegund (2331 ft.). The height of the mountains decreases considerably from this point towards both south and east; the Wechsel Group extends west of the Feistritz Valley, and also attains its greatest height in the northern part, where it contains the Umschuss (5617 ft.), the Hochwechsel (5700 ft.), and the Niederwechsel (5537 ft.) on the boundary of Styria and Lower Austria. The small group north of the Wechsel Group is the Semmering Group, which culminates in the Stuhleck or Spitaler Alpe (5847 ft.), with a remarkably extensive view; the Sonnwendstein or Göstritz (4994 ft.) in the north-east is also similarly distinguished. The famous Semmering Pass, on the western side of the Göstritz, leads over the mountains which form the boundary between Lower Austria and Styria. Though it is the lowest of the important Alpine saddles, no driving-road was carried across it until the year 1726; another, a fine high-road, was made over it in 1842. In 1854 the Semmering railway was completed.

The Semmering road virtually begins at Vienna and ends at Trieste. A pyramid erected at the top of the pass bears the inscription, "*Aditus ad Adriatici maris litora.*" The road is picturesque throughout, but its scenery is surpassed by that through which the railway passes. On the further side of the pass both road and railway lead past Spital (2522 ft.), in the green valley of the Fröschnitz, to the market-town of Mürzzuschlag (2203 ft.), a centre of the iron trade, and here the railway ends. At this point the Mürz comes into the valley from the north-west, and taking a turn follows the south-westerly

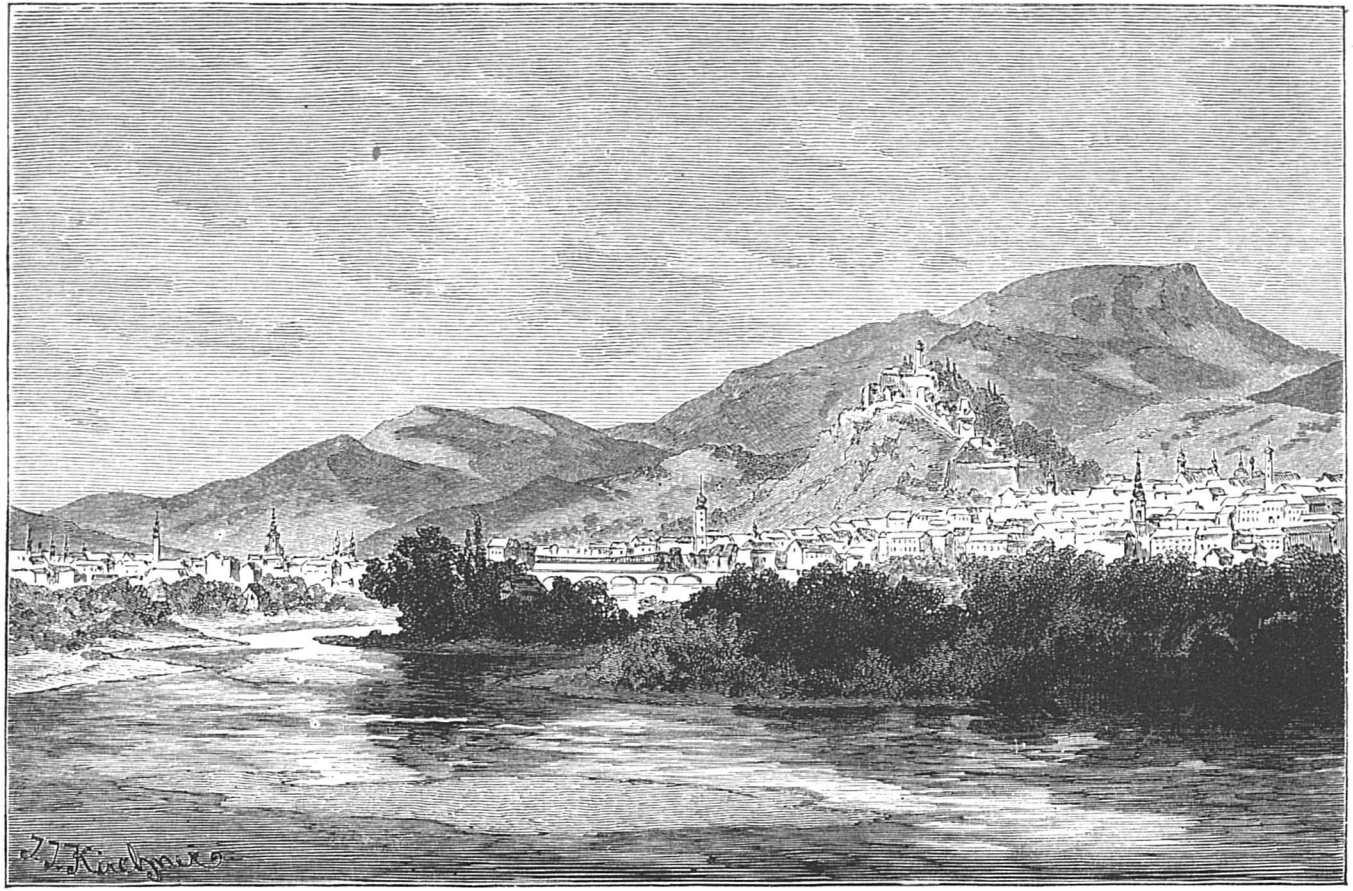
direction of the Fröschnitz. Krieglach (1966 ft.), Kindberg (1820 ft.), and Kapfenberg (1640 ft.), lie in the valley of the Mürz; at Bruck (1596 ft.) the river flows into the Mur. The Mur rises at the Marchkareck in the Pöllaer Alps, and flows through a great longitudinal valley which has an easterly direction as far as Judenburg, and from there to Bruck a north-easterly one. The upper valley of the Mur as far as Tamsweg (3348 ft.) is in Salzburg, and lies very high; it is called the Lungau, and the valley of the head-stream itself is called the Murwinkel. Below Tamsweg, the river has worn a deep outlet for itself which ends near Murau (2613 ft.). At Judenburg (2403 ft.) the valley of the Mur widens out into the broad fruitful Eichfeld. The Pöls Valley coming from the north-west, opens into the valley of the Mur, at this place; Judenburg, which is even at the present day surrounded by high walls, was from its position at the junction of several roads, an important emporium of the German and Italian trade in the middle ages. The Celtic settlement *Idunum* formerly stood here. At the lower end of the Eichfeld, Knittelfeld (2116 ft.) stands, and north-west of this place, in the Kobenzer Valley, is Seckau (2760 ft.), formerly the seat of a bishopric. St. Michael stands in the narrower part of the valley, at the mouth of the Liesing Valley, and the cheerful town of Leoben (1745 ft.), the largest in Upper Styria, stands at the opening of the Vorderenberg Valley. At Bruck the Mur turns at a right angle, and enters a transverse valley with a southerly direction, then it breaks away from the primitive mountains through which it has flowed up to this point. The valley is narrow also in this part, where the health-resort Frohnleiten (1423 ft.) is picturesquely built above the Mur, and the railway emerges from the defile, at the Badelwand, and the Peggau (1364 ft.) and the Gratwein (1292 ft.) are reflected in the water. Then the valley widens out into a broad, fertile cauldron, at the upper end of which Graz (1131 ft.), the beautiful capital of Styria, stands on both

sides of the Mur, bending round the rugged Schlossberg (2856 ft.). A French riddle designates it as, "*la ville des graces, sur la rivière de l'amour.*"

The Graz basin is broadest at the point where the Kainach Valley opens into it on the west. At Wildon (1032 ft.) it is separated from the Leibnitzer Feld (Leibnitz 902 ft.) by a narrow pass. At Ehrenhausen (846 ft.) the Mur approaches close to the Windischen Bühel, and is forced by it into an easterly direction; this begins the third section of its course. Radkersburg (682 ft.), near the Hungarian border, marks the lingual boundary between German and Sclavonian. For a long reach the Mur flows parallel to the Drave through a broad valley between flattened hills; those in the Mesopotamia between the Mur and the Drave belong to the Windischen Bühel. The eastern part of this river-bound district is called the Mur Island (in the Magyar, Muraköz).

### (*b*) The Northern Zone of the Eastern Alps.

1. The Kitzbühler Alps are bounded on the west by the Ziller Valley from Zell down to its mouth, and by the Inn from the mouth of the Ziller to the point where it emerges from the mountains; they extend eastward to the Bavarian plain, where Rosenheim (1465 ft.), Neu-Aschau (2019 ft.), Traunstein (1926 ft.), and Teisendorf (1653 ft.), mark the foot of the mountains; the Saalach and the Zeller Lake form the boundary on the east, and the Salzach from Bruck upwards to its source, the Gerlos Pass, and the Gerlos Valley on the south. Their name is derived from the transverse valley of the Kitzbühler Ache, which cuts through the group in the middle in a north and south direction. They cover an area of 1482 square miles. They stand in Tyrol, except a portion in the north belonging to Bavaria, in the east belonging to Salzburg, and some in the extreme south. They are composed, geo-



Graz, from the south.

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gnostically, of five parallel zones extending from east to west; the most southerly belongs to the primitive mountains and, proceeding northward, is succeeded by a Devonian zone, triassic rocks, Jura formations, and tertiary rocks. The Kitzbühler Alps, even near the Inn, are considerably higher than the neighbouring North Tyrolean limestone Alps on the farther side of the river; they are highest in the south-west and south-east, but do not reach the snow region. The Kitzbühler Alps proper lie south of the line Wörgl, Kitzbühel, St. Johann, Pass Griesen, and Saalfelden, which is that also followed by the railway. The main crest begins in the west with the Katzenkopf (8305 ft.), and Thorhelm (8171 ft.), north-east of Zell on the Ziller. North-east of the latter, above the source of the Salzach, is the Salzach Joch (6483 ft.), which connects Ronach in the Upper Pinzgau with Hopfgarten (2028 ft.), in the Brixen Valley. The Waibl (7354 ft.) and the Sonnen Joch (7495 ft.) stand north of the Katzenkopf. The Thorhelm in the main crest is succeeded on the east by the Wildalpspitze (7920 ft.), and then on the north-east by the Rettenstein (7744 ft.). East of the latter a road leads over the Pass Thurn (4171 ft.), from Mittersill (2561 ft.), on the Salzach, to Kitzbühel (2415 ft.), and St. Johann (2129 ft.), in the Achen Valley. Next comes the Pihapperspitze (8236 ft.), near which, to the north-west, are the Gamshag (7138 ft.), the Hochkogel (7258 ft.), and the Schmittenhöhe (6345 ft.). The latter peak affords one of the most extensive views in Lower Austria, and is one of the most easily ascended.

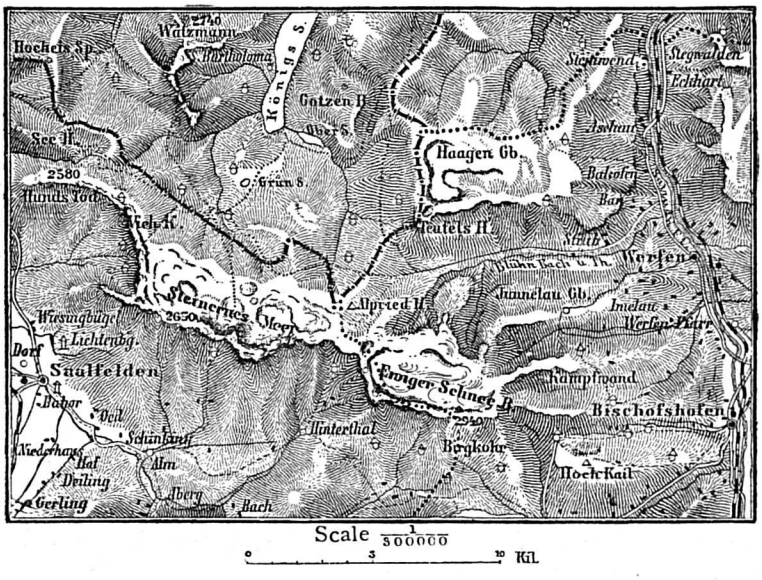
The Kaisergebirge range extends north of the Brixen Valley, between the Inn and Grossachen, as far northward as the depression in which the Walch Lake (2190 ft.) lies. It consists of two chains, separated from each other by the eastern and western Kaiser Valleys; the northern is the Hinteren or Zahmen Kaiser (6547 ft.), and the southern, the Vorderen or Wilden Kaiser.

The first is an extensive elevated plateau with steep sides, the last a mountain chain of the wildest character, its peaks being most difficult of access. Among these the highest are the Elmauer Haltspitze (7789 ft.), the Ackerlspitze (7646 ft.), and the Treffauer Kaiser (7558 ft.). On the south, the Hohe Salve (5081 ft.) is connected with the Kaiser range by the Elmauer saddle (2662 ft.). It is one of the easiest mountains to ascend, and is much visited for the sake of its fine view. Its summit, which is visible from a great distance, is covered with turf, and its lower slopes with fine woods, and farms; which extend half-way up the mountain. The outlying mountains north of the Kaiser range, which slope down to the Bavarian plateau, and enclose the Chiemsee Lake on the west and south, may be all grouped together under the name of the Chiemsee Alps. Of these the Geigelstein (5936 ft.) is the highest. The Kampenwald (5503 ft.) rises north-east of it, and the Hochgern (5729 ft.) stands on the further side of the Achen. The Staufen range stands east of the Chiemsee, between the Drave and the Saalach, and contains the Zwiesel (5949 ft.) and the Hochstaufen (5904 ft.). The Chiemsee 1681 feet above the sea, 15½ miles long, 9½ miles broad, 321 feet deep), is an important lake; it has on all sides a flat shore, and has the appearance of a desolate waste of water, for, like the larger Bavarian lakes, the Ammersee (1768 ft.) and the Würmsee (1944 ft.), which lie farther west, it is situated in the plain. But it lies much nearer to the mountains than the other two, and when seen from the northern shore the chain of the Alps appears to form a semicircle round it; it has the same effect from the three islands, which lie in the lake; these are, the Herren Island with a royal palace, the Frauen Island, and the Kraut Island, which is uninhabited. At the foot of the range are the smaller lakes, the Simsee on the west, and the Waginger-see on the east. The Chiemsee supplies the water of the Achen, the valley of which, the Great Acher Valley, leads

down the mountains to the Thurn Pass, which has been already mentioned. It is connected with the Saalach Valley by the Griesen Pass (3177 ft.), between St. Johann (2129 ft.) and Saalfelden (2377 ft.), and by the Strub Pass (2255 ft.), between Kirchdorf and Lofer (2095 ft.), which was formerly fortified. Enclosed by these pass roads and by the valleys of the Gross Achen and the Saalach, is the Loferer Steinberg group, containing the Breithorn (8211 ft.), and the Birnhorn (8637 ft.); the Pill Lake (2737 ft.) lies in a lonely spot in a short transverse valley.

2. The SALZBURG and BERCHTESGADEN ALPS form a distinct group, being surrounded by the Salzach Valley on the south and east, and by the Saalach Valley and the bed of the Zell Lake on the west; it is 546 square miles in extent, the central part belonging to Upper Bavaria, and the remainder to Salzburg. It is here that, going from west to east, we first meet with the magnificent limestone plateaus, of which we had a slight example in the Karrenalp of the Canton Glarus. This group is one of the highest of the limestone Alps. The broad mass of the Steinernes Meer extends in a bow, from the Pinzgauer Hohlwegen (a narrow pass on the Saalach) to the Pass Lueg, the rocky ravine through which the Salzach flows; towards the south it is massive, compact, and connected, towards the north cut up by deep valleys into separate mountain masses. Its highest peak is the Schönfeldspitze (8708 ft.), from which the great glacier-covered block of the Ewiger Schnee, or Übergossenen Alp, projects into the Salzach Valley; the highest point is the Hochkönig (9637 ft.). The southern outliers of the Steinernes Meer and the Ewiger Schnee, as far as the Lower Pinzgau, and the Pongau, are the less lofty Dientener Mountains. Great ridges of rock extend northwards from the Steinernes Meer, and rise, in the Watzmann, the highest point of the eastern grat, to a height of 8986 feet, and in the Hochkalter, the highest point of the western, to 8623 feet. The

Blaueis glacier, on the latter is the most northerly glacier in the Alps. The Watzmann, the king of the Berchtesgaden Alps, rises majestically in the form of a gigantic pyramid above the green mountains to the north, its bare jagged peaks of greyish white emerging from the snowfields at their feet. Between the Watzmann and the wild Hachelwand (at the Hachelkopf, 6652 ft.), in a deep, narrow ravine, is the Eiskapelle (2753 ft.), a dome-shaped hill of ice, 212 feet in length, the




The Steinernes Meer and Ewiger Schnee.

mighty remnant of an avalanche, from underneath which a stream descends in spray. A ridge extends from the eastern end of the Steinernes Meer north-eastward to the wild Hagengebirge, a jagged limestone block, between the Blühnbach Valley on the south, and the Blüntau on the north; the grey weatherworn rocks are partially covered here and there with thin sparse grass, or with stunted firs. The two Teufelshörner (7777 feet and 7505 ft.) rear their heads on the southern border. The range of the Hagengebirge is separated by the

Torrener Joch (5168 ft.) and the Blüntau from the beautiful rounded summit of the Hohen Göll (8263 ft.), from which four sections branch out symmetrically in bare grey ridges, which a little lower down are covered with a mantle of vegetation. The broad mass of the Untersberg is an outpost of the highlands of Berchtesgaden running out towards Salzburg; its highest peak, the Berchtesgadner Hochthron (6478 ft.), affords a fine and extensive view. The Kolowratshöhle, with its plain of ice, 164 feet wide and 212 feet long, is a very interesting cavern; it was discovered first in 1845.

The three chains of mountains named above, determine the course of the three main valleys of the Berchtesgadner district, the Seethal, containing the lake, the Königsee, lying between the Hagengebirge and the Hohen Göll on the one side, and the Watzmann on the other side, the desolate and sterile Wimbach Valley between the Watzmann and Hochkalter, and the Hintersee Valley, containing the Hinter Lake (2604 ft.), between the Hoch Kalter and the western flank of the Reiteralpe (containing the Reitalphorn, 5745 ft.).

These three valleys run parallel to each other from south-south-east to north-north-west, and uniting below Ramsau (2173 ft.) form the lovely and varied Berchtesgadner Valley, which runs northward towards the valley of the Salzach. The important market-town of Berchtesgaden (1888 ft.) stands in the valley; it is famous for its wood-carving and its salt-mines. The surrounding neighbourhood is of exquisite beauty, the crowning point being the Königsee or St. Bartholomew Lake (1976 feet above the sea, four square miles in extent, 704 feet deep). Its dark water lying between overhanging limestone rocks, gives it the appearance rather of a Norwegian fjord than of an Alpine lake. The pilgrimage Church of St. Bartholomew, and a royal hunting-palace stand on a peninsula at the mouth of the Eisbach where it flows into the lake. The lonely little lake, the Obersee, is separated from the Königsee at its upper

end by a narrow strip of land. A waterfall descends in spray from the Kaunerwand into this lake.

The Salzach Valley which bounds the Berchtesgadner Group on the south and east should be traced from its beginning. The Salzach emerges from two small lakes on the Salzacher Hochlahn, north of the Gerlos Pass, but judging from the supply of water, the Krimmeler Ache, which rises in the Tauern ridge, should be considered as its source. It flows first through a longitudinal valley, with an east and west direction, nearly to St. Johann: it does not lie like the Valley of the Inn between the limestone Alps and the Central chain, but between the latter and the transition mountains of the Kitzbühler Alps and the Dientener mountains, and has not therefore the beauty and variety of the Inn Valley. The climate of the Salzach Valley is not so mild as that of the Inn Valley; in the latter, important places stand on both sides of the river and on the terraces of the mountain sides, in the Salzach Valley only places of bygone prosperity are found on the sunny side of the hills. The terrible marshiness of the valley (especially from the overflow of the Mittersill, 2724 ft.), has not only affected the prosperity of its inhabitants, but has also undermined their bodily constitution: deformity is not unusual in the Salzach Valley. The stillness of the valley, the stern aspect of nature in it, and its gloomy legends combine to give a melancholy tone to it. From St. Johann to Salzburg, however, the valley has another aspect; it is here transverse, cutting in rapid succession through transition mountains, limestone mountains, outlying mountains and hills. In this portion it is even more lovely than the Inn Valley. The whole of the upper Salzach Valley, from its beginning at Ronach (4660 ft.), nearly to Taxenbach (2332 ft.), as well as the district of the Saalach, is called the Pinzgau, which is divided into the Upper Pinzgau, from the beginning of the valley to Piesendorf, the Lower Pinzgau, from Piesendorf, through Zell (2452 ft.), to Taxenbach, and the Middle Pinzgau, the district of the Saalach as far as it

belongs to Salzburg. The middle Valley of the Salzach, from Taxenbach as far as the Pass of Lueg, belongs to the Pongau; the lower valley bears the name of the Salzachgau. Opposite the mouth of the Kapruner Valley the deep depression of the Zell Lake (2424 feet above the sea, two square miles in extent, 238 feet deep), the waters of which are carried off by the Saalach, strikes far northwards into the mountain. To the north it passes into the Prielauer Moss, to the south into the Zeller Moss. It is only in the middle of the lake, therefore, that the full beauty of its surroundings can be thoroughly appreciated, the view to the south towards the Tauern being especially lovely. The market-town of Zell am See (2452 feet), stands on the western bank, at the foot of the Schmittenhöhe. The transverse Valley of the Salzach, running northward, begins at St. Johann (1846 ft.), in the Pongau, and below Werfen (1704 ft.) is the gap between the Hagengebirge and the Tennengebirge, one of the most magnificent narrow passes in the Alps. Near its exit, and just at the narrowest part, is the Pass Lueg, which was fortified as early as 1316, and offered a firm resistance to the French in the years 1800, 1805 and 1809. Below this pass are the Salzach Öfen, ravines in which great masses of rock lie in wild confusion, all overgrown with bushes, while the river dashes along far below. The Salzach has so undermined the rocks here that they have fallen together, one above another, so that the river runs under a gigantic archway. The river enters the Salzachgau at Golling (1560 ft.), where the valley is much wider. Near this town the Schwarzbach forms the fine double cascade of the Gollinger Fall (202 feet high). The lower Valley of the Salzach is cheerful, and is beautifully cultivated, and is bordered on the right by the outlying hills, but on the left by the lofty limestone peaks of the Berchtesgadner group. In this valley, the old salt-mining town Hallein (1453 ft.), stands at the foot of the Dürnberg. The next town is Salzburg (1351 ft.), the fortress of the Salzach, and the capital of the province

of the same name. It is the *Juvavum* of the Romans. Until the year 1802 it was the seat of an ecclesiastical principality, and even at the present time shows the character of its former splendour in numerous churches, marble buildings and fountains, which, with the flat roofs of the houses built in the Italian fashion, have gained for it the name of "the Rome of Germany."

The Saalach flows into the Salzach, below Salzburg. The bath of Reichenhall (1570 ft.), is picturesquely situated in the Valley of the Saalach, surrounded on three sides by a beautiful sweep of mountain. It is the meeting-place of the four Bavarian salt-towns, which are connected with each other by salt-conduits fifty miles long; these are, besides Reichenhall itself, Berchtesgaden, Traunstein on the Traun, and Rosenheim on the Inn. Reichenhall is connected with Berchtesgaden on the south, by the road through the Hallthurn Pass (2252 ft.), and with the Ramsau by a second road, through the Pass of the Schwarzbachwacht (2918 ft.). The fortified road of the Stein Pass leads from the middle Valley of the Saalach to the Bavarian and Austrian boundary. The narrow Knie Pass follows immediately on the health-resort Unken (1810 ft.), near which is the Schwarzberg or Unkner Klamm, and then the Lofer (2095 ft.), with its beautiful surroundings. A carriage-road leads from the Pinzgauer Hohlwegen, already mentioned, over the Hirschbichel (3857 ft.), into the Ramsau. The middle Valley of the Saalach ends immediately north of the Zell Lake; the upper valley, the Glemm Valley, runs parallel to the upper Valley of the Salzach, and extends westward as far as the source of the stream on the Trist Saddle (6360 ft.), below the Saalkopf.

3. The SALZKAMMERGÜT and ENNS ALPS, or the UPPER AUSTRIAN ALPS, are bounded on the west by the Salzach, from Salzburg to St. Johann, on the south by the Little Arlbach, the Wagreiner Höhe, and the longitudinal Valley of the Enns as far as

the bend at Hieflau, on the east by the transverse Valley of the Enns as far as Steyer, on the north by the line through Salzburg (1351 ft.), Neumarkt, Strasswalchen (1774 ft.), Frankenmarkt (1758 ft.), Timmelkam (1551 ft.), Böcklabruck (1420 ft.), Gmunden (1393 ft.), Voitsdorf, Kremsmünster (1084 ft.), Hall (1232 ft.), and Steyr (996 ft.), passing into the Upper Austrian Highlands. The western part belongs to Salzburg, the southern part to Styria, and the remainder to Upper Austria, the whole covering an area of 2220 square miles. With the exception of a narrow zone of transition rocks, in the south-west, this group is composed of a broad girdle of triassic limestone rocks, between which the dachstein belonging to the Rhætian formation forms numerous elevated plateaus. On the north this is followed by a narrower zone of neogene sandstone. The western part of the Alps of Upper Austria is distinguished by a thick layer of salt of the Lower Trias (at Aussee, Hallstadt and Ischl), forming the so-called Salzkammergut.[1] To the south-west (*a*) the TENNENGEBIRGE rise between the Salzach on the west, the Little Arl Valley, the Wagreiner Saddle, and the Enns on the south, the valleys of the Mandlingbach and the Upper Lammer on the east, and the Lower Lammer Valley on the north. It is a mountain block 7217 feet high, with rugged flanks which slope considerably towards the Valley of the Salzach. The principal peaks are the Raucheck (7964 ft.), the Bleikogel (7901 ft.), and the Wieselsteinkopf (7530 ft.). A carriage-road leads from Werfen on the Salzach over the watershed at Hüttau (2807 ft.), to Radstadt in the Valley of the Enns, and from there a road goes over the Wagreiner Saddle (3121 ft.), to St. Johann in the Pongau; a branch of the Eisela railway also follows the first route. Golling is connected with Abtenau (2335 ft.), or the Lammer

[1] Kammergut was the name formerly given to a domain of the lord of the land, hence Salzkammergut means a domain producing Salt. The name appears first in the year 1379.

Valley, by a road over the Strub-Berg (2610 ft.), and the latter is connected with the Gosau Valley by a bridle-path over the Zwieselalpe (5195 feet). (*b*) The DACHSTEIN GROUP is bounded on the west by the Upper Lammer Valley and the Valley of the Mandling Bach, on the south by the Valley of the Enns from the Mandling Pass to Steinach, on the east and north by the lower Valley of the Grimming Bach, Mitterndorf, the Kainisch Valley, the basin of Aussee, the Traun, the road over the Pötschen Pass from St. Agatha to Steg, the northern end of the Hallstätter Lake, the Gosau Valley and the Pass Gschütt as far as the Lammer Valley. Being, like the Berchtesgadner Alps, cut off from its surroundings by deep gaps, it contains the greatest masses and highest elevations of the northern Alps, east of Lake Constance. They are divided into a central block and the various ridges radiating from it. Of these sections the huge Grimming (7713 ft.), in the east, and the Sarstein (6472 ft.), in the north, appear quite isolated, being cut off by the ravines of the Salza and the Traun respectively; the Gosauer Stein (6724 ft.), in the west, the Hallstätter Salzberg group, containing the Plassenstein (6467 ft.), in the north, and the Kammergebirge, containing the Hocheck (8964 ft.), in the east, are less sharply separated from the central block. The Dachstein group is a dreary elevated plateau of 5250 to 7220 feet in height, with numerous cauldrons, platforms, and ravines, all surrounded by lofty peaks. On the north the central block slopes down steeply to the Hallstätter Lake, and the southern side still more steeply into the Valley of the Enns, where the wooded hills of the Ramsau form its foot. The highest peaks, the Dachstein (9827 ft.), and the Thorstein (9657 ft.), are in this part, and are separated from each other by a deep depression. Besides these the range contains ten peaks over 8200 feet high. The most easterly glaciers of the Alps are found in the Dachstein group. These are the Hallstätter or Karls-Eisfeld, the Schladminger, the Gosauer, the Ramsauer,

the Schneeloch and the Thorstein glaciers. The largest of these is the Karls-Eisfeld, which is enclosed between the grey points of the Hochkreuz (9069 ft.), the Dachstein, the two Dirndln, the Hunerkogel, the Koppenkarstein, and the Hohen Gjaidstein (9138 ft.); it is nearly two and a half miles long, and one and a half miles broad.

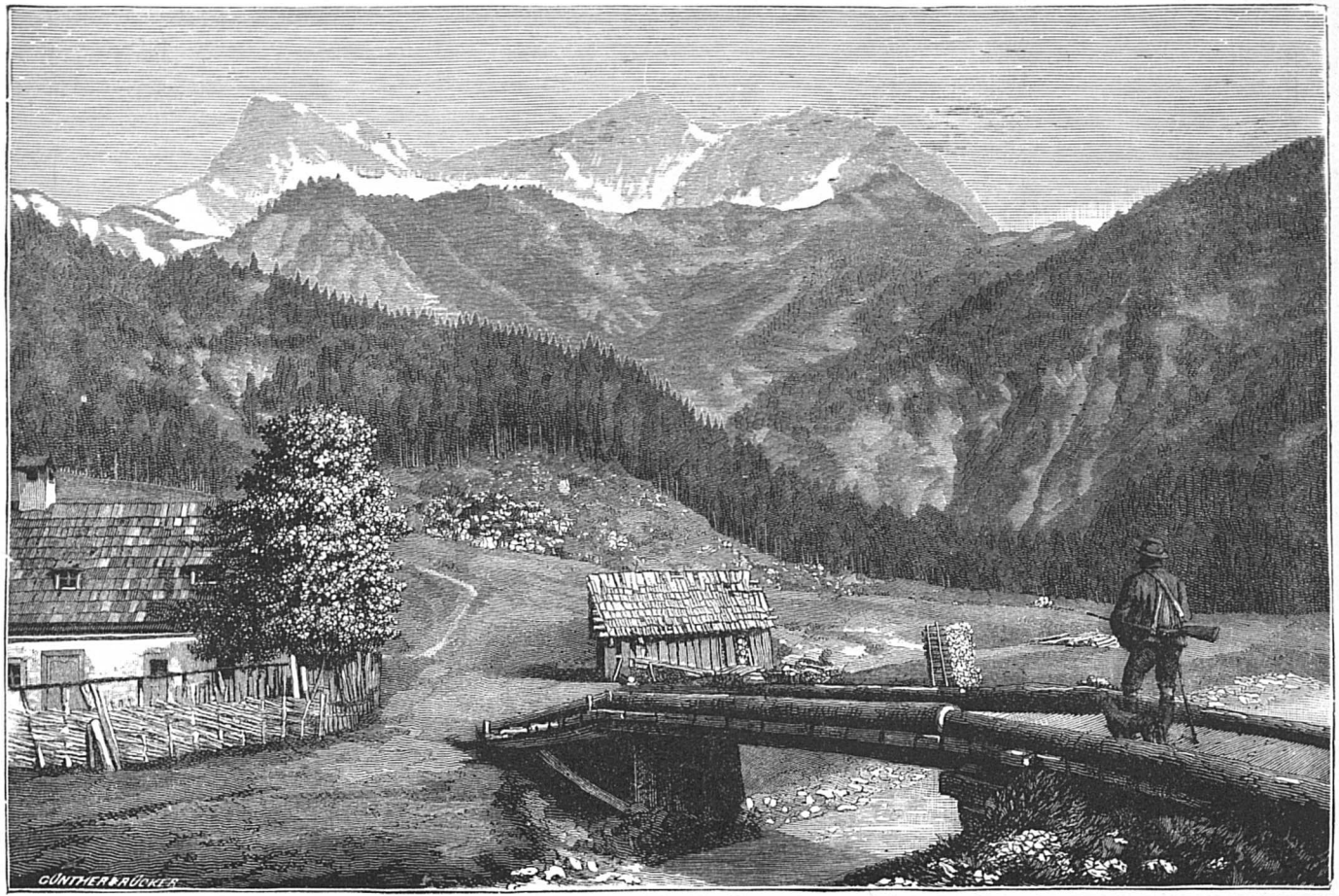
The Dachstein contains the triple boundary of Upper Austria, Salzburg and Styria. On the north a road leads from the Hallstätter Lake through the lower Gosau Valley, and over the Pass Gschütt (3183 ft.), into the Lammer Valley and to Golling; both road and railway cross the Radling saddle, leading from Steinach (2105 ft.), on the Enns, to Aussee (2154 ft.), a health-resort, beautifully situated on the Upper Traun.

(*c*) The ISCHLER mountains are enclosed by the Gosau Valley, the Pass Gschütt, and the Lower Lammer Valley on the south, the Salzach from Golling to Salzburg on the west, by the passage at Hof, the Fuschel Lake, the St. Wolfgang Lake and the Ischl Valley as far as Ischl, on the north, and the Traun as far as Steg, and the Hallstätter Lake as far as the mouth of the Gosau Valley, on the east. Its peaks are not so high, nor so precipitous in form, as those of the neighbouring groups, only the very highest peaks reaching the Alp region. The main crest, the eastern part of which is called the Ramsau range, extends south-west, from Hallein to the Hallstätter Lake; the principal peaks in it are, the Gamsfeld (6640 ft.), the Hoher Zinken (5869 ft.), and the Kahlenberg (5985 ft.). To the east, near Salzburg, stands the Gaisberg (4206 ft.), much visited for the sake of its fine view, which includes seven lakes, and the northern limestone Alps from the Traun Lake to the Inn, while above it rise the Ankogel, the Wiesbachhorn, and the Grossglockner. A road leads from Salzburg over the Pass Reitberg (2522 ft.), to the Lake of St. Wolfgang.

(*a*) The HOLLENGEBIRGE Group, is bounded on the south by the Fuschel Lake, the Lake of St. Wolfgang, and the Valley of

the Ischl, on the east by the Traun and the Traun Lake, on the north and west by the Mond Lake, the Atter Lake, and the Ager. The Höllengebirge itself is a limestone block, which extends east and west between the upper parts of the Traun and Atter Lakes, and is bounded on the south by the two streams of the Weissenbach; on the north it gradually descends by means of the range of the Fichtau, to the Ager. It rises precipitously for the most part from the surrounding valleys, its upper surface being much hollowed out and torn. The culminating peak, the Great Höllenkogel (6106 ft.), does not exhibit so fine a panorama as the Kranabit saddle (5594 ft.), from which a magnificent view over the Salzkammergut and the Styrian Alps is obtained. The Ziemitz, containing the Leonsberg (5717 ft.), rises north of the two streams of the Weissenbach, over the watershed of which a driving-road leads from the Traun Valley to the Atter Lake; joining the Leonsberg on the west is the Schafberg (5837 ft.), which from its situation and the beauty of the view obtained from it, is sometimes called the "Rhigi of Austria."

(*e*) The TODTE GEBIRGE is bounded by the Traun Lake and the Traun on the west, the Steier as far as Dirnbach, the Teichel and the Pyhrn road as far as Liezen on the east, and by the Enns from Liezen to Steinach, the lower Grimmingbach, Mitterndorf, the Kainisch Valley, Aussee, and the road over the Pötschen Pass on the south; to the north it descends into the Upper Austrian Highlands, affording a striking example of the cleavage, the weathering, and the absence of vegetation in the upper plains of the limestone Alps; a horrible desolation weighs upon the landscape, and all life seems to have fled from this labyrinth of rock. Its broad plateau resembles the "Steinernes Meer," only it is not so high. On the northern border are the peaks of the Hohe Schrott (5847 ft.), the Zwölfer Kogel, and the Grosse Priel (8246 ft.), the latter being the culminating point of the whole group. The Teufels




Hinterstoder.

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Mauer extends from the Grosse Priel to the Kleine Priel (7001 ft.). The Priel block closes the western end of the beautiful Cauldron Valley of the Hinterstoder, in which the Steier rises, while on the east and south it appears to be enclosed by the high masses of a more isolated group. The Tragelspitze (7135 ft.), the Thorstein (7769 ft.), and the Warscheneck (7826 ft.), are in this latter group. The Weisse Wand (7179 ft.), north-west of the Tragelspitze, is closely connected with the main mass of the Todten Gebirge, on the southern border of which the Reichenstein may be noticed, from which the Trisselwand (5871 ft.), like the Weisse Wand, projects, opposite the Valley of the sources of the Traun. Chains and mountain blocks of considerable size form the outliers of the Todten Gebirge, such as the chain between the Alm and the Steier, which culminates in the Kasberg (5720 ft.), and the superb pyramid of the Traunstein (5446 ft.), on the eastern shore of the Traun Lake, which dominates the country round. (*f*) The block of the PYRGAS GROUP is separated from the Todten Gebirge by the road over the Pass Pyhrn (3099 ft.), between Liezen and Windischgarsten; on the south the group extends along the Enns from Liezen to Admont; on the east it is enclosed by the line through Admont, St. Gallen, and Altenmarkt, and on the north by the Laussagräbens. A road existed over the Pass Pyhrn as early as the Roman period, and coming from Upper Italy also crossed the Rottenmanner Tauern; a hospice or hospital for travellers, merchants, and pilgrims was established on this pass in the year 1190. Another carriage-road goes from Admont over the Wenger saddle or Buchauer Berg (2788 ft.), to St. Gallen in the Buchau. The highest peaks of this group are the Grosse Pyrgas (7360 ft.), the Grosse Scheiblingstein (7217 ft.), and the Hochthurm (6819 ft.), which rise north of Admont in the so-called "Haller Mauern," past the village of Hall. (*g*) The BUCHSTEIN GROUP is connected with the Pyrgas at the Wenger saddle; it is bounded on the south and east by the Enns from

Admont to Altenmarkt, and on the west by the Buchau. Approaching the Hochthor opposite in the Eisenerze range, it contracts the Gesäuse, the Valley of the Enns between Admont and Hieflau. It culminates in the Grossen Buchstein (7294 ft.).

(*h*) The SENGSEN or SENSEN GEBIRGE, north-west of the Priel block, and north of Pyrgas and Buchstein, is bounded on the south by the Laussagräben, on the west by the Teichel and Steier, on the east by the Enns ; to the north it reaches as far as the point where the Steier falls into the Enns. The highest peak, the Hohe Nock (6431 ft.), has an extensive view. Lower peaks are the Hochsengsen (6021 ft.), to the north-west, and the Grosse Alpenkogel (5057 ft.), to the north-east. A driving-road leads over the Hengst saddle, from Windischgarsten (1970 ft.), on the Teichel, to Altenmarkt (1510 ft.).

The most important valleys of the Upper Austrian Alps are those of the Traun and the Enns, and of these the Traun takes precedence. It is the last of the lake rivers on the northern side of the Alps, and has no less than eighteen lakes within its range. The Aussee is the centre of the district where its sources lie. The main source comes from the Weissenwand, and flows through the lovely little lake, the Kammersee (2357 ft.), the Toplitz Lake (2348 ft.), not much larger, and the beautiful Grundel Lake (2325 feet above the sea, four miles long, more than half a mile wide), at the southern foot of the Trisselwand. The Alt Aussee Lake (2325 ft.) lies at the western foot of the Trisselwand, and the little Öden Lake (2505 ft.) on the eastern flank of the Kammergebirge. The streams from these lakes, the Grundelsee Traun, Altsee Traun, Aussee Traun, and the Odensee or Kainisch Traun, unite below Aussee, and form the Traun, which turns with many curves towards the south-west, and flows into the Hallstätter Lake (1629 feet above the sea, three and a half square miles in extent, 409 feet deep) at upper Traun, at the northern foot of the Dachstein. At this point and

at its outlet its shores possess much beauty, but for the most part it is bounded by lofty rugged rocks, which give it the gloomiest aspect of all the larger Upper Austrian lakes. Lahn stands at the south-western corner, with its houses built in the manner of Southern Europe ; for two entire months in the winter, no ray of sunshine reaches it. Near it is the celebrated Celtic burial-ground, where about a thousand graves have been discovered since 1846. A little further to the north the houses of the market-town of Hallstatt are seen clinging to the mountain side like swallows' nests. Then comes the opening of the Gosau Valley, which runs first to the west, and afterwards penetrates the Dachstein mass to the south and south-east and encloses the beautiful Vorderen Gosau Lake (2978 ft.), and the smaller Hinteren Gosau Lake (3763 ft.). The Traun flows out of the Hallstätter Lake in a northerly direction, through the lovely basin of Goisern (1640 ft.), and reaches the well-known watering-place of Ischl (1533 ft.) in the salt district, where it receives the Ischl river flowing from the green lake of St. Wolfgang, or the Abersee (1742 feet, five and a half square miles in extent, 369 feet deep) at the foot of the Schafberg. From this place the Traun flows towards the north-west, then passing through a beautiful green plain, enters the basin of the splendid Traun Lake (1383 feet above the sea, nine square miles in extent, 623 feet deep). This lake is one of the most beautiful, both on account of the contour of the mountains round it, and of its gradual change from sublime grandeur to the softest beauty. From the southern shore it has the appearance of a dark mass of water entirely shut in by mountains. The northern shore presents a complete contrast where the pleasant town of Gmunden (1392 ft.), formerly the chief town of the Salzkammergut, winds round the lake with its hills and villas, and Traun Kirchen stands on a point projecting into the lake. The Traunstein rises out of the lake, about midway along the eastern shore, with almost perpendicular brown flanks. The Traun,

when it leaves the lake, passes from the high to the lower mountains, among which it flows with a strong, rapid descent, and at Roitham (1429 ft.) forms the picturesque Traun Falls (45 feet high) which go into the "Gute Fall" canal, the steepest navigable stream known. At Lambach (1099 ft.), outside the Alp district, the Traun receives the Ager on its left bank, which is also a lake-river. The lonely Fuschel Lake (2095 ft.), and the long, narrow Zell or Irr Lake (1748 ft.), both flow out of the Mond Lake (1560 feet above the sea, nine square miles in extent, 222 feet deep). A short stream from the southern end of the latter lake, into which the rocks of the Schafberg descend precipitously, connects it with the Atter or Kammer Lake (1527 feet above the sea, eighteen square miles in extent, 560 feet deep). This is the largest lake of the Salzkammergut, but it is surpassed in beauty by the Traun Lake. Its waters are carried off by the Ager.

On the further side of the Ager and Traun, towards the Danube, are outlying hills of sandstone, in numerous branches, composed partly of terraces and partly of swelling undulations, the most important being the Hausruckwald. This is a wooded chain of mountains with many branches, rich in brown-coal and culminating in the Göblberg (2590 ft.). Its south-western end, as far west as the Mattig, is called the Kobernauser Forest. The Kürnberg (1719 ft.) at Linz, projects as far as the Danube. The Sauwald (2871 ft.), near the mouth of the Inn, is granite, and from its composition belongs rather to the Bavarian Forest than to the outlying Alps.

The Enns, which bounds the group on the south and east, is through its whole course parallel to the Salzach. It rises on the northern slope of the Radstädter Tauern, whence it rushes down northwards through the Flachau Valley; but even before reaching Radstadt, it changes its northerly direction for an easterly one. It then flows as far as the bend at Hieflau, through a large longitudinal valley, which is an eastern extension of the main

valley of the Inn and the Salzach. The Enns belongs to Salzburg, as far as the Pass Mandling (2655 ft.); the northern side of the valley here is composed of transition rocks which hide the chain of high limestone mountains behind them, while on the southern side the Tauern range with its lofty bare limestone crest skirts the valley. The brown primitive rocks appear again in the Tauern in the place of the limestone, at Mandling, but on the north the green wooded mountains fall back, and the limestone chain appears in its whole extent sloping towards the Enns Valley, and having only a low stage of hills below it. Not until Liezen (2161 ft.) is reached is the limestone again hidden behind groups of high wooded hills, through the gaps of which beautiful glimpses of the chain are obtained. The Enns Valley is broad, being only slightly contracted where mountains of *débris* are thrown out from the side valleys, and here it becomes marshy. As the Enns receives no tributaries from glaciers and very few from lakes, it is neither so bright a green as the Traun, nor so milky as the Salzach and the Inn, but is of a dark olive green colour. The river breaks through the principal chain of the limestone Alps, in the magnificent defile of the Gesäuse, below Admont (2101 ft.), where there is a celebrated Benedictine monastery, founded in 1074, and then turns northwards at Hieflau (1694 ft.) and breaks through other lower series of the northern Alps; there is consequently a succession of narrow passes and valley basins in the Enns Valley, from that place to Steyr. At Altenmarkt in the latter part of the valley, the river passes from Styria into Upper Austria.

4. The NORTH STYRIAN ALPS, also called the Eisenerzer Alps, which are 842 square miles in extent, and lie entirely in Styria, are bounded on the west by the Palten Valley, the Walderhöhe, and the stream of the Liesingbach, on the south by the Mur from St. Michael to Bruck, and by the Mürz Valley as far as Mürzzuschlag, on the north by the same valley up to Mürzsteg, by the Dobrau Valley, the Niederalpel, the Aschbach

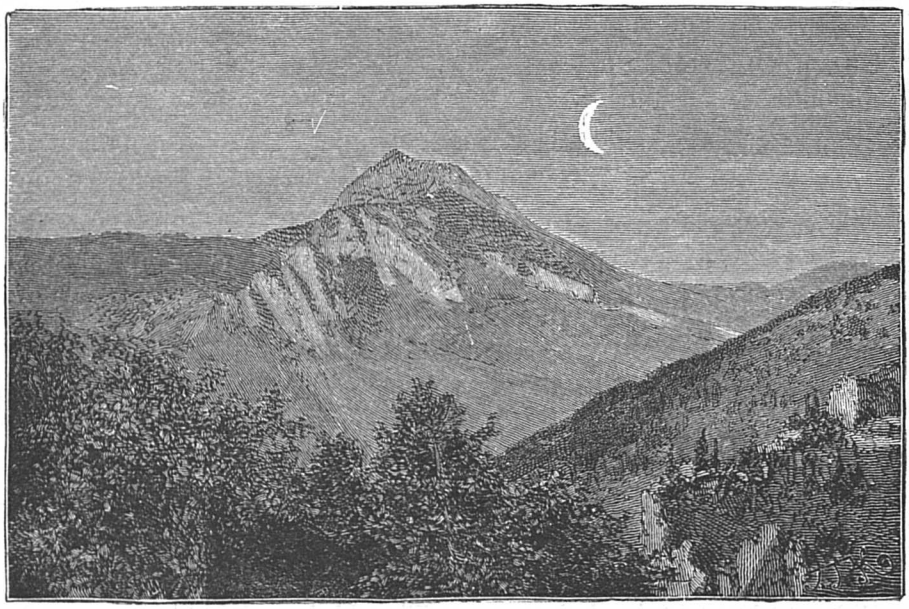
Valley, the Styrian Salza from Gusswerk to its confluence with the Enns, and from there by the Enns up to Selzthal. Its geological composition mainly consists of three parallel zones, extending east and west; a zone of triassic limestone on the north, one of silurian transition rocks in the middle, and one of crystalline schist on the south. The North Styrian Alps, though they do not reach the snow-line, are distinguished by their perpendicular form; in the middle section plateau formation is found, similar to that of the Karst. The most westerly group, which is bounded on the east by the Vordernberger Valley, the Prebichl, and the valley of the Erzbach from Eisenerz to Hieflau, is the Reichensteiner Gebirge. It culminates in the Hochthor (7780 ft.), which descends precipitously to the Gesäuse; the peaks nearest to it are the Hoch-Zinödl (7184 ft.) to the east, and the Ödstein (7659 ft.) to the south-west. The Reichenstein (7370 ft.) and the Sparafeld (7364 ft.) to the west, are separated by the beautiful Johnsbach Valley. The Lugauer (7233 ft.) rises east of the Hochthor block, and on the other side of the Radmer Valley is the Fölz group, containing the Hochkopf (6908 ft.), and the Kaiserschild (6831 ft.). On the southern side of the Reichsteiner Gebirge, are the Zeiritzkampel (6969 ft.), and the Reiting (Gösseck, 7265 ft.). The road which turns into the Vordernberger Valley at Leoben forms an important pass; it leads through the iron-mining town of Vordernberg (2690 ft.), over the Prebichl, or Eisenerzer Tauern (4056 ft.), to Eisenerz (2443 ft.). The latter lies at the foot of the celebrated Styrian mountain the Erzberg (5030 ft.), which is literally an iron mountain; the greater part of the mass is so rich in metal that in summer it is worked "open cast" and in winter by means of adit levels. Much of the ore that is obtained here supplies the iron industry in what was formerly called the "Eisenwurzen," the manufacturing valleys of the Ips and Erlaf. The "Eisenstrasse," which leads to it, is a continuation of the road over the Prebichl, going through the valley of the Erzbach.

The little Leopoldsteiner Lake (2028 ft.), with its dark green water, lies north-west of Eisenerz, and the Frauenmauerhöhle, a cave with ice formation, to the east, in the Gsollgraben. The Hochschwab group stands between the Prebichl road on the west, and the line through the Aschbachthal, Gollrad, the Pass of Seewiesen (or Seeberg, 4113 ft.), Seegraben, Aflenz, and Thörlgraben on the east, which is followed by a road from Gusswerk on the Salza, to Kapfenberg on the Mürz. The principal chain consists of the fairly massive limestone block, which extends from Eisenerz to the Seeberg, and is bounded on the north by the longitudinal valley of the Salza, while on the south its transverse ridges, which sometimes rise to lofty peaks, run out to the valleys of the Liesing, the Mur and the Mürz. The Hochschwab (7482 ft.), is the highest peak of the whole district. Like most of the limestone Alps, the body of the range forms a kind of elevated plain, much scalloped out at the edges, but in spite of its stony ground, possessing many excellent Alp pastures, and consequently supporting large numbers of chamois. The Brandstein (6570 ft.), the Ebenstein (6965 ft.), the Hochweichsel (7364 ft.), the Ringkamp (7063 ft.), and the Aflenzer Staritzer (6523 ft.), are the high peaks and corners of this great platform. From the Hochschwab, the whole panorama of the range from the Grossglockner and Dachstein as far as the Hungarian plain, from the valley of the Danube to the Triglav, lies spread before the view, like a sea of crests and peaks, but no valley nor human habitation can be seen, all being hidden by the broad base of the Hochschwab. On the summit stands a cast-iron monument, which was erected in honour of the Archduke John, who frequently visited the mountain. The most easterly group of the North Styrian Alps is the somewhat isolated Hochveitsch group, containing the Hohen Veitsch (6501 ft.) which is the culminating peak; the Rosskopf (4863 ft.) stands east of it. A road leads through the Mürz Valley, which bounds this group on the north, leading

from Mürzzuschlag, through Neuberg (2399 ft.), with its great iron works, to Mürzsteg (2567 ft.), then through the Dobrein Valley, over the Niederalpel (4000 ft.), to Wegscheid (2665 ft.), in the Aschbach Valley, and thence to Gusswerk (2446 ft.), and Mariazell (2826 ft.).

5. The LOWER AUSTRIAN ALPS are bounded on the west by the Enns from Steyr up to Gross Reifling, on the south by the Styrian Salza as far as Gusswerk, by the Aschbach Valley as far as Wegscheid, the Niederalpel, the Dobrein Valley, the Mürz Valley from Mürzsteg to Mürzzuschlag, through the Fröschnitz Valley and the Semmering road to Gloggnitz, on the east by the Vienna basin south of the Danube; on the north they pass into the Lower Austrian Highlands, along the line, Steyr (990 ft.), Waidhofen on the Ips (1172 ft.), Scheibbs (1048 ft.), Wilhelmsburg (1032 ft.), the Traisen, Pyhra (960 ft.), Böheim Kirchen (786 ft.), Neulengbach (789 ft.); the boundary from Neulengbach is formed by the Tulner Bach, as far as its discharge into the Danube, and the latter river as far down as Vienna (544 ft.). According to Leipoldt they cover an area of 1603 sq. miles, and belong to Lower Austria, except the extreme western part, which is in Upper Austria, and the extreme south, which is in Styria; the prevailing limestone zone in the south is of the triassic and Jura formation; a narrow zone of sandstone is joined to this in the north, and is of the neocene flysch formation. The gradual breaking up of the range, towards the east, into more or less isolated groups is very striking, as are also the block formation of the branches, and the Karst character of the higher portion of the range, while the lower chains are green and well-wooded. The highest elevations are found principally along the Styrian boundary. The range at first decreases in height towards the east, then rises again, and reaches its greatest elevation in the extreme south-east, but even there remains far below the snow-limit. The groups between the Enns, the Salza and the Erlaf may be classed

together as the group of the Voralpe and the Ötscher. Single massive mountain blocks are connected with each other by short branches. The Voralpe (5801 ft.), rises near Altenmarkt on the Enns; this is succeeded farther to the east by the Gösslinger Alps, containing the Hochkar or Hochkohr (5801 ft.), and then by the Kräuterin, containing the Hochstadt (6297 ft.). North of the latter is the Dürrenstein or Dürnstein



The Ötscher.

(6155 ft.), a repetition of the Steinernes Meer; at its foot are the three little Lunzer Lakes, which discharge their waters into the Ips, at Lunz. The Ötscher, or Hötschaberg (6206 ft.), stands north-east of the Dürrenstein, being separated from it by the Ips. This mountain, with its holes and caverns, is rich in legend, and has a magnificent view. Its eastern front is washed by the Erlaf, which has its source near the celebrated pilgrim-station of Mariazell (2826 ft.), and forms the pretty lake, the Erlafsee (2738 ft.); the Lassingbach falls into

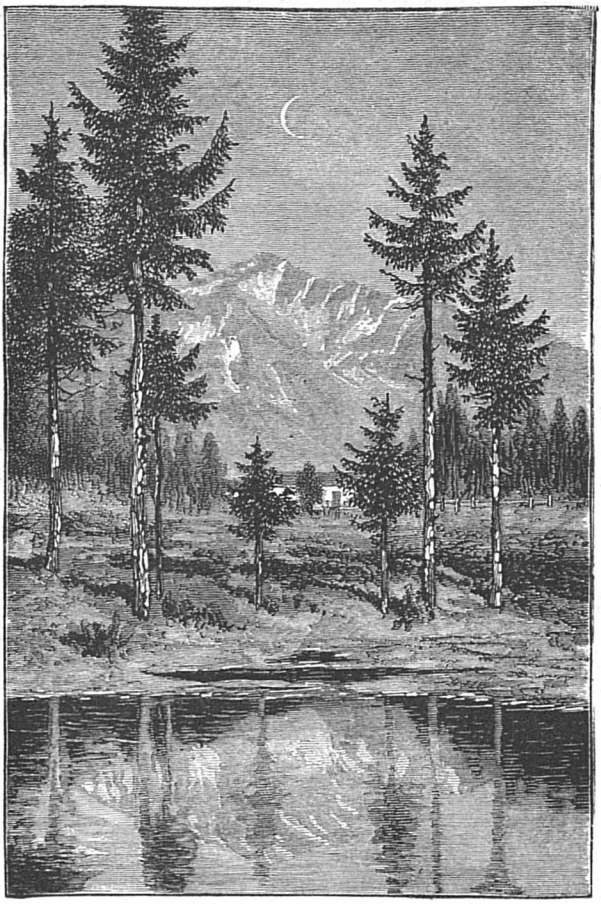
it at Wiener Brückl in a triple cascade, 412 feet high, in a ravine overgrown with brushwood. North of the Otscher the Erlaf flows through the romantic defile of the Thormäuer. The Student (5030 ft.), and the Tonion (5575 ft.), form a group by themselves, situated between the Salza Valley, the Aschbachgraben, the road over the Niederalpell, and the Upper Mürz Valley. The group of the Schneealpe and the Raxalpe stands east of the last group. The Mürz bounds them on the west south-west, and north-west, from Kapellen (2308 ft.), to the Raxen Valley, then the saddle of the Preiner Gscheid (3508 ft.), the Preiner Bach, from Reichenau (1596 ft.), down the Schwarza Valley as far as the "Singerin," and the northern Prein Valley. The Raxalpe (highest point the Heukuppe, 6590 ft.), is a plateau-like mountain block descending precipitously on every side, and having the Karst formation; the Schneealpe (6245 ft.), which is separated from it by the Nasswald Valley and the Altenberger Valley, has a similar character. The Gippel (5466 ft.) stands north of the latter, and west of the Gippel is the Göller (5865 ft.). The huge Schneeberg (6806 ft.) is separated from the Raxalpe by the narrow part of the Schwarza Valley between Reichenau and the Singerin, called the Höllenthal; it is the highest mountain in Lower Austria. Its prominent position permits a particularly fine view to be obtained from it. The Hohen Wand (3722 ft.) extends north-east from the Schneeberg, like a wall of rock, as far as the Piesting Valley. The Traisengebirge forms an extensive group which is bounded on the west by the Grosse Erlaf, south by the line through Mariazell, St. Egyd, and Rohr, east by the road which leads from Schwarzau through the Gölsenbach Valley, while on the north it passes into the Lower Austrian highlands along the line Wilhelmsburg and Sheibbs.

The stream of the Bielach and the two streams of the Traisen (the Türnitzer Traisen and the Hohenberger Traisen) flow

through this group. The Vienna and Mariazell road leads through the Valley of the Türnitzer Traisen, and before it comes to an end has to cross the three saddles of the Annaberg (3177 ft.), the Josefsberg (3230 ft.), and the Knieriegels (2765 ft.). The highest peak of the Traisen mountains is the Reisalpe or Hochalpe (4584 ft.), south-east of the old Cistercian colony of Lilienfeld (1166 ft.), which lies as high as the region of brushwood, and affords a splendid view. The Unterberg group extends east of the Traisengebirge and north of the Schneeberg and the Hohen Wand. Its northern boundary is formed by the valleys of the Gölsen (which flows to the Traisen) and the Triesting (flowing to the Schwechat), which are connected by the saddle of the Gerichtsberg (1885 ft.); the railway between Leobersdorf and St. Pölten also follows this line. The culminating peak, the Unterberg (4398 ft.), rises north-west of the market-town of Gutenstein, which is picturesquely situated in the Piesting Valley. Frederick the Fair spent his last days in the fortress of this town. The Wiener Wald, which is composed of limestone in the southern portion, and of sandstone in the northern portion, is separated from the Lower Alps and Alps by the Gölsen and Traisen, and extends between the Tulnerbach and the Vienna Basin as far as Vienna; it separates into several branches, and in the Schöppel, on the Upper Schwechat, reaches the height of 2928 feet, in the Hohen Lindkogel or Eisernen Thor, west of the ancient watering-place Baden (694 ft.), where the Schwechat emerges from the mountains, it reaches 2724 feet. The Western railway, from Vienna to Linz, cuts through the northern part of the Wiener Wald, and at Rekawinkel (1180 ft.), crosses the watershed between the little river Wien and the Tulnerbach. The short range of the Kahlengebirge (Hermannskogel, 1777 ft., Leopoldsberg, 1472 ft.), runs eastward, from the Tulbinger Kogel (1623 ft)., to the Tulnerfeld. The Hermannskogel throws out beautiful wooded spurs towards the south which extend under the

names of Kobenzl, Himmel, and Gallitzinberg to the celebrated imperial summer-palace of Schönbrunn.

The fertile and well-wooded mountains and highlands of



The Schneeberg.

Lower Austria, extend northwards between the Enns and the Tulnerbach to the Danube, and on the south are parted from the Alps by the line given above. They do not bear the Alpine character. The forest-covered mountain group of Göttweih, the Dunkelsteiner Wald, between Melk and Mautern, belongs

geognostically to the granite plateau of Austria, on the left bank of the Danube.

(*e*) THE SOUTHERN ZONE OF THE EASTERN ALPS.

1. The LESSINIAN ALPS are bounded on the west by the Adige (Etsch), from Verona up to Trient, on the north by the Lower Fersina, the watershed at Pergine, the Caldonazzo Lake, and the Upper Brenta, and on the east by the Middle Brenta; on the south they sink down between the Adige and the Brenta, into the Upper Italian plain, where Verona (165 ft.), Montebello, Malo, Schio and Bassano (469 ft.), stand at the foot of the mountains. The north-western part belongs to Tyrol, the greater half, to the south-east, to Venice; their entire extent is 1100 square miles. The highest peaks lie along the Austrian-Italian boundary, and nowhere reach the snow region. From the boundary they sink into secondary mountains in the direction of the valleys of the Adige (Etsch) and Brenta to the west and north, while to the south-east they gradually sink into extended chains of hills. The name Monte Lessini is applied only to the part of the range north of Verona, which contains the Cima tre Croci (6622 ft.), and within which the "thirteen Communes" (tredici Communi) lie. The inhabitants of the latter are, like those of the "Sette Communi" farther to the north-east, the last remnants of the German-Lombardian races who wandered into Italy in the early part of the middle ages, and though cut off from all connection with the Germans, have preserved their ancient dialect here among the mountains. Italian, however, is rapidly being introduced, and will shortly supersede the last remnant of the old German language. The chief town of the thirteen communes is Badia Cavalegna, on the Torre d'Illasi, an affluent of the Adige, north-east of Verona. The Cima di Posta (7179 ft.), rises to the north of the Cima tre Croci, and is the culminating peak of the extremely rugged chain which stretches northward, between the Adige and the Arsa, to Roverto. North-east of the Cima di Posta, a carriage-road which was

made in 1817 under the Emperor Francis I., goes from Vicenza (98 ft.), and Schio, over the plain of Fugazze (4206 ft.), into the Arsa Valley, and to Roverto (712 ft.); immediately to the south of it, a bridle-path leads out of the Arsa Valley over the Passo Buse Scure to the well-known baths of Recoaro. North of the plain of Fugazze is the Monte Pasubio (7319 ft.), which is followed, in the same direction, by the Col Santo (6921 ft.), then to the north-east by the Monte Laste (6757 ft.), and the Cima Mandriola (6717 ft.), and finally on the Brenta, the Cima Dodici (7646 ft.), the highest peak of the whole group. Between Monte Pasubio and Monte Laste a bridle-path leads over the Borcola Joch (4000 ft.), from Tiene in the Valley of the Torrente Astico, to Roverto, and north of Monte Laste, a cart-road goes from the same valley over the watershed at Folgario (3814 ft.), to Calliano in the Valley of the Adige. A less important road from Trient turns into the narrow Fersina Valley behind Pergine (1580 ft.), crosses the Colle di Pergine (1797 ft.), then descends to the small lake of Levico (1435 ft.), and enters the Val Sugana at the little town of Levico in the Brenta Valley, thence following the Sugana as far as Bassano. A narrow ridge of mountains only, separates the Levico Lake from the fine Caldonazzo Lake (1465 feet), out of which the Brenta flows. The district of the "Sette Communi," the seven German communes, which since 1797 have formed a republic under the protection of Venice, lies south of the Cima Dodici, between Astico and Brenta. The chief town is Asiago (3265 ft.), situated in a park-like basin, with numerous hollows, and streams that disappear into the earth. The Lessinian Alps are chiefly of limestone, belonging to the Jura formation, the chalk formation appearing only in the south, while in the eastern border there is a considerable amount of basalt, belonging to a volcanic zone, which is continued in the small isolated group of the Berician Mountains (Monte Berici, 1344 ft.), south of Vicenza, and in the Euganeen (Colli Euganei,

1374 ft.), south-west of Padua, which has numerous hot springs.

2. The CADORIC ALPS, or SOUTH TYROLEAN DOLOMITE ALPS, are bounded on the west by the Adige between Trient and Botzen, thence by the Eisak to Brixen, and then by the Rienz, on the north by the Rienz and the Toblacher Feld, on the east by the Sextenbach, the Kreuzberg saddle and the Piave Valley, and on the south by the Fersina Valley, the Levico Lake, the Brenta Valley, and the Venetian plain between Brenta and Piave, where Bassano (469 ft.) Asolo (1022 ft.), and Nervesa mark the foot of the mountains. The extensive district they cover, containing 2672 square miles, is divided between Tyrol (on the west and north) and Venetia (on the south-east). The Cadoric Alps are among the most interesting of the Alps, and vary most from the general type. The western part is formed of a zone of red porphyry, extending from Botzen, where it first appears in the flanks of the valley cauldron, to Trient. Black augite porphyry appears with it, especially at Predazzo in the Fassa Valley, on the Seisser Alp, in the Gader Valley, and in the Val Agardino. To the south the granite mass of the Cima d'Asta breaks through. A strip of red sandstone and conglomerate lies in the crystalline schist, and is followed by grey muschelkalk and then thick black sandstone. In the mountains to the east, however, important folds of triassic dolomite appear. The whole district, therefore, exhibits a varied mixture of different kinds of rocks, and consequently of plants, animals, and people.

The group of the Peitler Kofel (9425 ft.) rises to the north-west at Brixen, and south of it the huge wild peaks of the Geislerspitzen (10,437 ft.), tower aloft, being separated from the former group by the Vilnös Valley. The group of the Peitlerkofel, and that of the huge Seekofel (7243 ft.), standing opposite to it, enclose the Enneberg Valley, and the Abtei Valley (Badia), which together open into the Puster Valley at

St. Lorenz, while the Grödner Valley (Goerdeina), to the south of the Geislerspitz, runs into the Eisak Valley at Waidbruck. The beautiful little lake, the Pragser Wildsee (4850 ft.), lies at the northern foot of the Seekofel, in the south-western branch of the Pragser Valley, in which are also the well-known baths of Alt Prag (4516 ft.), and Neu Prag (4345 ft.). The southern side of the Grödner Valley is bounded by the Seisseralpe, an elevated plateau 4590 feet high in the middle, and about fifty miles in circumference. It is the largest and most beautiful Alp in Tyrol. In summer upwards of 1100 head of cattle feed upon its pastures, more than seventy herdsmen's huts, and 360 hay-sheds, appear on the green plain like a distant village. The rock which underlies the thick green covering is black augite porphyry, but the plain is enclosed by a wall of white or reddish dolomite, from which rise sombre bare cliffs of curious form. These, however, are flattened on the top, where there are small tracts of thin grass and on them are scattered peculiar heaps of rock, like mole-hills, in the clefts of which are seen deep fissures of apparently unfathomable depth. The neighbouring mountain block, with the fine peak of the Schlern (8400 ft.), shows the same formation. To the east the Rosszähne (9167 ft.) form a connection with the Rosengarten (10,406 ft.), which presents a unique picture of jagged points, clefts, and platforms. The sunlight has a remarkably beautiful effect on the dolomite peaks of this range, tingeing them with an exquisite glow in the early morning, or at sunset.

The Valley of Karneid (the Eggenthal) separates the last named group from the extensive group of the Fassaner Alps, which is surrounded on both sides by the valley of the Avisio which stretches north-east. This valley, which is over sixty miles long is the largest of the collateral valleys of the Adige, except the Eisak-Rienz district. It has three stages; the lowest is called the Zimmers Valley or Val di Cembra, it extends from Lavis (743 ft.), where the Avisio flows into the plain of the Adige

through a narrow gateway of rock to the Val Floriana. The middle stage, the Fleimser Valley (Val di Fiemme) extends as far as Moëna (3873 ft.); it is an Alpine valley of moderate width, enclosed by mountains for the most part overgrown with pine-trees interspersed with green meadows, villages and single houses; the principal place is Cavalese (3230 ft.). The upper stage, the Fassa Valley, penetrates to the centre of the

The Vedretta Marmolata.

dolomite Alps, on the eastern side of the Rosengarten. At its upper end the Vedretta Marmolade or Marmolata (11,462 ft,), the "Queen of the Dolomites," rises boldly, covered towards the north with an icy mantle and falling precipitously towards the south. Its nearest neighbour to the south is the Sasso di Val Fredda (9793 ft.). This is succeeded towards the south by the Cima di Lastei, the Cima di Vallon, the Cima di Lagorei (8571 ft.), the Cima d'Asta (8833 ft.), and Mont Scalet, or Kreuzspitze (8155 ft.), all on the left side of the Avisio Valley; on the

right side are the Schwarzhorn (7993 ft.), the Weisshorn (7583 ft.), and the Lattemar (8980 ft.). The Valley of the Avisio is connected with the neighbouring valleys by numerous passes; thus, a road leads over the saddle of San Lugano (3597 ft.) from Cavalese to Auer in the Valley of the Adige, a bridle-path over the Passo Costalunga (5739 ft.), from Moëna to Kardaun; a cart-road leads over the saddle of Pordoi (7390 ft.), from Canazei in the Fassa Valley into the Upper Cordevole Valley and a bridle-path over the Sella Joch (7313 ft.), and another over the Passo di Fedaja (6655 ft.), from Caprile in the Valley of the Cordevole, lead into the same valley. The beautiful Cismone Valley, which opens into the Brenta Valley on the south, is reached from Predrazzo (3334 ft.) in the Fliemser Valley by crossing the Rolle, or Costonzella Pass (6480 ft.). Its chief place is Primiero (Germ. Primör, 2345 ft.). An interesting dolomite group rises north of Primiero, including the Pala Group or Group of Primör, the Cima di Vezzana, the Cimon della Pala (10,966 ft.), the Cima di Ball (10,838 ft.), and the Pala di St. Martino (10,841 ft.), which is very difficult of ascent, and is called the "Matterhorn of the Dolomites." The picturesque Cordevole Valley is situated east of the Cismone Valley, with which it runs parallel for the most part; it begins north-west of the Vedretta Marmolade, at Monte Pordoi in the Sella Group (culminating point Cima di Boè, 10,337 ft.). The upper part, which stretches eastward, is called the Livina Longo or Buchenstein. The beautiful lake of Alleghe (3217 ft.) is situated beyond Caprile (3373 ft.), past the point where the valley takes a southerly direction; its formation was the result of a landslip from Monte Forca in 1772. From the mouth of the Canale Valley, the Cordevole Valley is called the Val d'Agordo. The chief town in it, Agordo (2060 ft.), with its environs, forms one of the loveliest spots in the Dolomite Alps. Beyond Agordo the mountains again approach each other, great masses of rock rising on either side. Both river and road go

Toblach, at the entrance of the Höhlenstein Valley.

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through this narrow pass, called the "Canal di Agordo," the former turning southward to the Piave, and the latter eastward through the hilly land to Belluno.

The Ampezzaner Alps form the eastern portion of the Cadoric Alps. The Ampezzaner road (Strada d'Allemagna), which is much used, leads into them, from the Puster Valley. It turns southward on the Toblacher Feld (3949 ft.) into the Höhlensteiner Valley, through which the Rienz flows, and past the little Toblacher Lake (4043 ft.) with its dark waters; to the west the jagged peak of the Dürrenstein (9301 ft.) rises, and to the east, are the glacier-covered summits of the Drei Schusterspitze (10,366 ft.). The Valley of the Black Rienz opens out on the left at Höhlenstein (Ital. Landro, 4614 ft.), its background being filled by the sparkling peaks of the Drei Zinnen (9718 ft.). Just beyond the town is seen the light green surface of the Dürren Lake, which is often dried up in the autumn, and behind all are the huge masses of Monte Cristallo (10,694 ft.) with its glaciers, and near it Monte Popena (10,600 ft.) and the Cristallin (9314 ft.), forming altogether a magnificent picture. Between Monte Cristallo and the Hoher Gaisl (Croda Rossa, Rothwand, 10,277 ft.) the road ascends the lovely Schluderbach (4730 ft.), on the German and Italian boundary, to the flat watershed (4992 ft.) between the Rienz and Boita, thus reaching the Ampezzo district. Passing the Lago Bianco (4863 ft.), Ospitale (4857 feet) is reached in a lovely situation, then the narrow pass of Peutelstein, where the Boita Valley turns sharply to the north-east. From this point the Valley is called the Ampezzo Valley. The first important place is the Cortina d'Ampezzo (3996 ft.), in a splendid position between the Tofana (10,703 ft.) on the west, Monte Cristallo on the north-east, and the Sorapiss, (10,796 ft.) on the south-east. The Colle della tre Croci (5952 ft.) leads between the two latter, into the neighbouring Anziei, Valley, which opens into the upper Valley of the Piave. The Misurina

Lake (5890 ft.) lies near the source of the Anziei; from it a carriage-road leads over the Colle di San Angelo, to Höhlenstein. The chain of the Monti Marmarole (9725 ft.) extends east of the Sorapiss, and south of that chain is Monte Antelao (10,670 ft.), at the foot of which the Boita unites with the Piave. Pieve di Cadore (2906 ft.), the chief place in the Cadore Valley, lies on the eastern side, beautifully situated on a rocky promontory

The Sella from Kolfuschg.

above the Piave. The Cadore Valley is the name given to the Piave Valley from this place to the mouth of the Anziei, and the entire group of mountains is named from it.

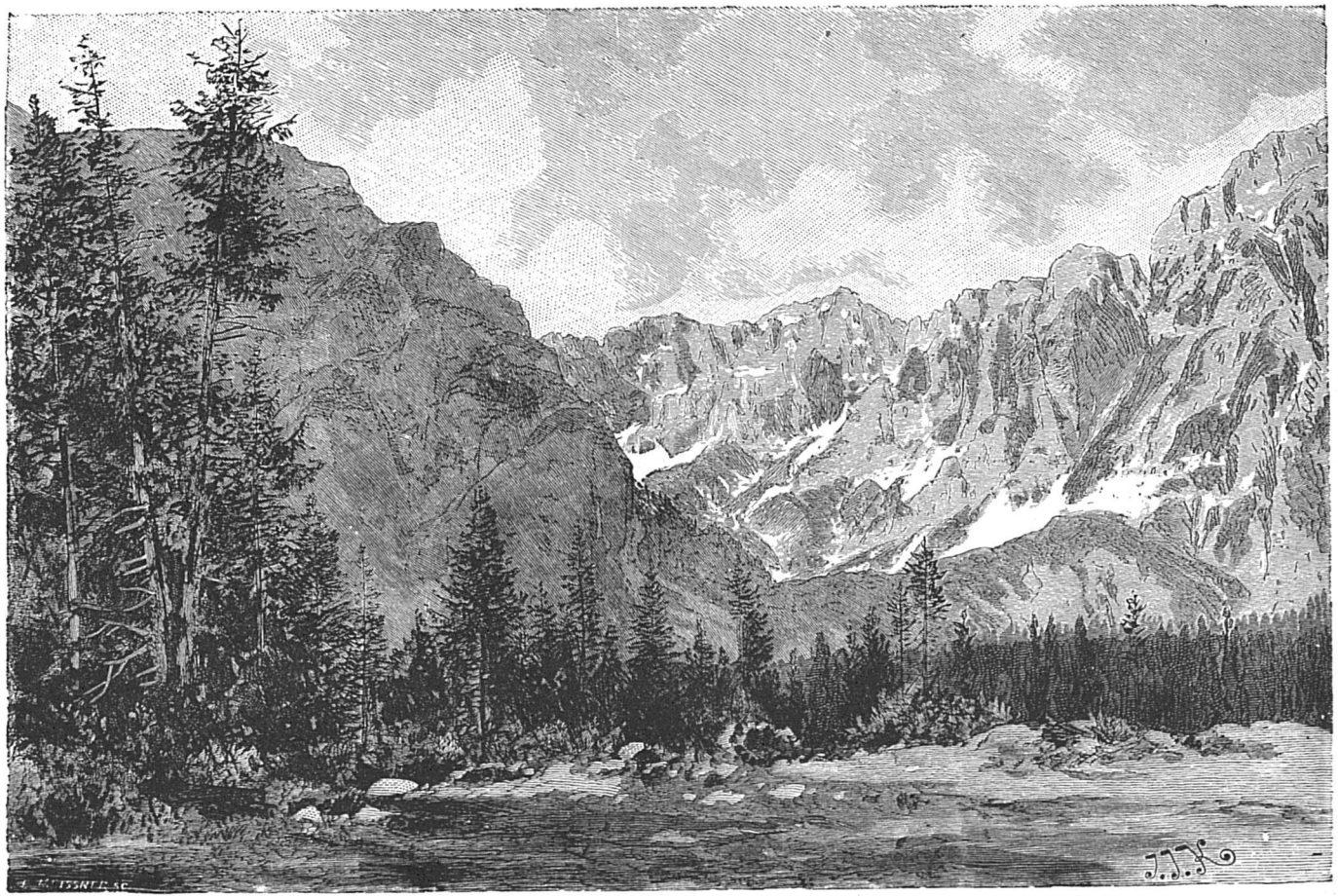
3. The VENETIAN ALPS or the PREMAGGIORE GROUP, extend on the west and north to the Piave, then to the saddle of Sappada (4273 ft.), on the east to the valley of the Degano and of the Tagliamento, and sink down on the south on a line indicated by the following places:—Valdobbiadene (767 ft.), Ceneda (469 ft.), Aviano (761 ft.), Maniago (666 ft.), and

Castelnuovo (1147 ft.). They cover an area of nearly 1116 square miles. They stand entirely on Venetian ground. Though they resemble the Ampezzaner Alps in construction and form, they are far less considerable in height, and do not reach at any point into the snow region. Monte Schiavon rises opposite the Monte Marmarole, in a chain which extends along the eastern side of the Piave, and opposite to Monte Antelao is Monte Cridola (8472 ft.), the culminating point of the whole group. Between these two mountains the Passo di Monte Mauria (4306 ft.) leads by a cart-road from Lorenzago to Piave in the upper Valley of the Tagliamento. The Cima di Lares (8780 ft.) stands south-west of the Cridola, and Monte Premaggiore (8124 ft.) east of the Cima di Lares between the Meluzzo Valley and the Upper Tagliamento. The chain of mountains which extends along the left bank of the Piave maintains the southerly direction, while the river turns to the south-west, at Capo di Ponte (1186 ft.). The chain just mentioned contains the Monte Maggiore, and Monte Cavallo (7373 ft.), and ends with the Col Maggiore (7620 ft.) close to the plain. At Capo di Ponte, the Canal di Santa Croce opens out; the lake of Santa Croce (1223 ft.) lies in this deep depression, which separates the south-western part of the Venetian Alps from the main mass. The culminating point of this part is the Col Vincentino (5875 ft.), south-east of Belluno (1263 ft.). The Clapsavon (8102 ft.), east of the Cridola in the district watered by the affluents of the Tagliamento on its right bank, and by the Livenza, should be mentioned, as well as the less elevated Monte di Verzegnis (6277 ft.), south-south-east of it.

4. The CARNIC ALPS are bounded on the west by the Sexten Valley, the Kreuzberg saddle and the Upper Piave; on the south by the latter, the saddle of Sappada, the Deganobach, the Tagliamento as far as the mouth of the Fella, by that river and the watershed at Saifnitz; on the east by the Canal Valley, the Gailitz, and the Gail as far as its discharge into the Drave,

and finally by the Drave from the mouth of the Gail to the Toblacher Feld. The area covered by this range is 1851 square miles; the greater part stands in Carinthia, a small part in the north-west belongs to Tyrol, and the southern part extends into Venetia; the southern main crest contains the boundary between the latter on the one side, and Tyrol and Carinthia on the other. This boundary range is composed of schist of the so-called Gailthal beds, crowned with high limestone peaks. The chain immediately to the south of the Drave is a picturesque range of triassic limestone which lies on crystalline schist. The latter appears along the Gail Valley to the south, separating the Trias range on the north from the Gailthal beds on the south. The northern triassic limestones are rich in lead, in the eastern part. This group is separated into the Carnic Alps or South Carnic Alps, and the Northern Gailthal Alps.

(*a*) The South Carnic Alps form a huge mountain chain extending east and west, the highest peaks of which approach very nearly to the snow-line; it throws out short branches to the Gail Valley, and longer ones in the angle between the Degano, the Upper Tagliamento and the Fella. The Helm or Helmspitze (7970 ft.) rises east of the Sextenbach; a carriage-road leads from the valley of this stream over the saddle of the Kreuzberg (Monte Croce, 5351 ft.), into the Piave Valley. The Pfaunspitze (8761 ft.) is situated south-east of the Helmspitze, its neighbour to the south being Monte Quaterna (8099 ft.). The Rosskarspitze stands south of the Kartitscher Joch or Tauern (5074 ft.), which connects the Kartitscher Valley with the Gail Valley. On the southern side of the latter valley are the peaks of the Hochspitze (8453 ft.), and the Paralba or Hochweiss-stein (8827 ft.), the culminating point of the whole chain. This is followed by Monte Volajo (7996 ft.), at the eastern foot of which the little Wolayer Lake (6550 ft.) lies in the midst of magnificent surroundings. Farther to the east is the Collinkofel (9217 ft), near which a carriage-road crosses the



The Hintere Seissera.

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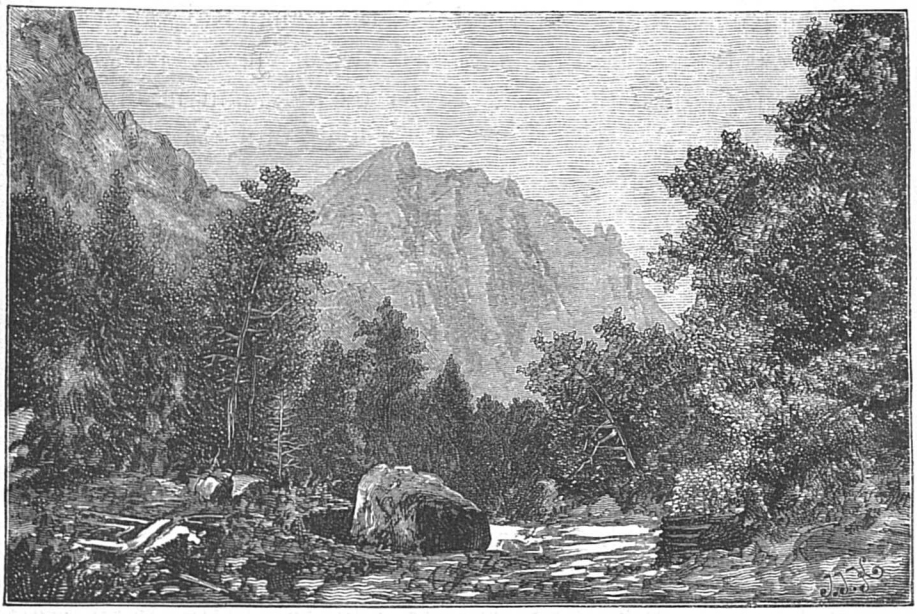
main crest, by the Plöken Pass (Monte Croce, 4460 ft.), and leads from Mauthen in the Gail Valley, to Tolmezzo in the Valley of the Tagliamento. Next come the Polinigg (7653 ft.), the Hoher Trieb (7217 ft.), and the Gartner Kofel (7215 ft.). From this point to the east, between the Gailitz and the Gail the main crest becomes considerably lower, reaching barely 6560 feet. One of the most important of the Alpine roads leads through the

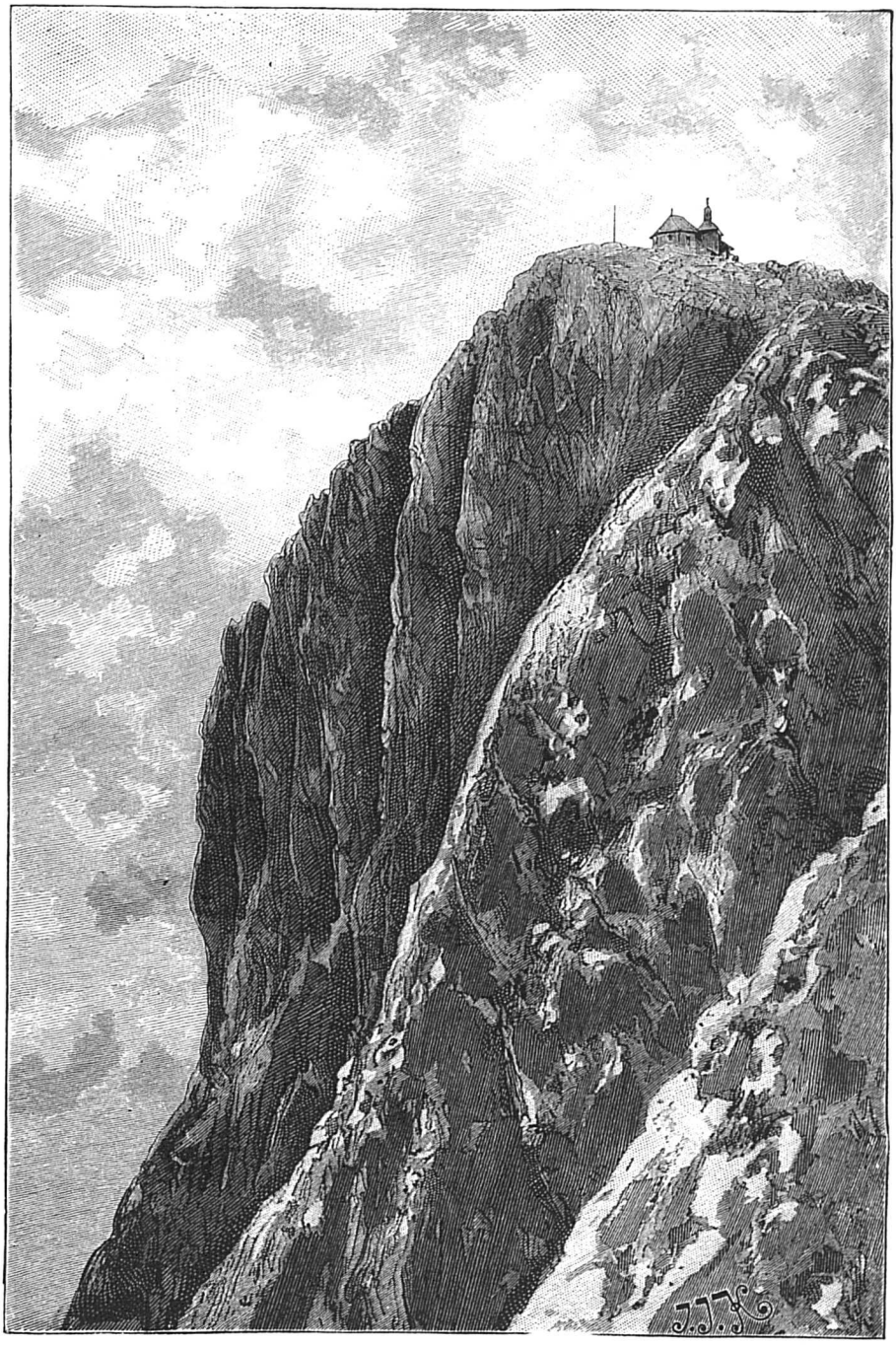


The Collinkofel.

Pontebba Pass or Pass of Malborghet. The road goes from Villach on the Drave, up the Gail Valley, as far as Arnoldstein (1935 ft.), then turns south-west into the Gailitz Valley, through which it continues as far as Tarvis (2405 ft.), the chief town in the valley. Passing the northern foot of the Luschariberg (5878 ft.), it ascends to Saifnitz (2656 ft.), where it reaches the watershed between the Schwarzen Meer and the Adria. The road, then gradually descending, passes the entrance of the splendid Seissera Valley to the south, and continuing in the Valley of the Fella,

reaches Malborghet (2364 ft.), with the fortress of the same name containing a monument which was erected in memory of the heroic defence of the place by Captain Hensel, in 1809. From this place the Austrian frontier-town of Pontafel (1865 ft.) is soon reached; it is entirely German, while the little town of Pontebba (1849 ft.), on the other side of the Pontebbana, the stream which forms the boundary, is as completely Italian. The road then follows the course of the Pontebba Railway, which joins the Rudolf Railway at Tarvis and the Italian Railway at Pontafel, and is the shortest connection between Vienna and Venice. The greatest difficulties had to be overcome in making the railway through the tract of country from Pontebba to Chiusaforte (1278 ft.), through the narrow rocky valley of the Fella (Canal di Ferro), the nature of the country necessitating a succession of galleries, tunnels, bridges, and viaducts. The valley does not expand again till beyond Resiutta (1035 ft.), where it opens out into the Tagliamento beyond Stazione per la Carnia (973 ft.).

(*b*) The GAILTHAL ALPS consist of a southern chain which extends east and west, from the Kartitsch Valley to the short transverse valley of the Gail at Villach; with this there is connected on the north a smaller triangular range, between the Weissensee Valley on the south, and the valley of the Drave, from Greifenburg to Sachsenburg, and thence to Paternion. The Hohe Staff (7282 ft.) and the Latschur (7341 ft.) are the culminating peaks of this triangular group, which is called the Staff Group. The elongated lake, the Weissensee (3037 feet above the sea, four and a half miles long, 309 feet deep), has most varied scenery, its shores possessing a wild grandeur where it is enclosed by massive rocks, a peaceful charm where it lies in the midst of grassy meadows, and a solemn gloom where it is overshadowed by thick woods. The southern chain of the Gailthal Alps begins on the west with the huge range of the Unholde, in which are the peaks of the



The Precipice of the Dobratsch.

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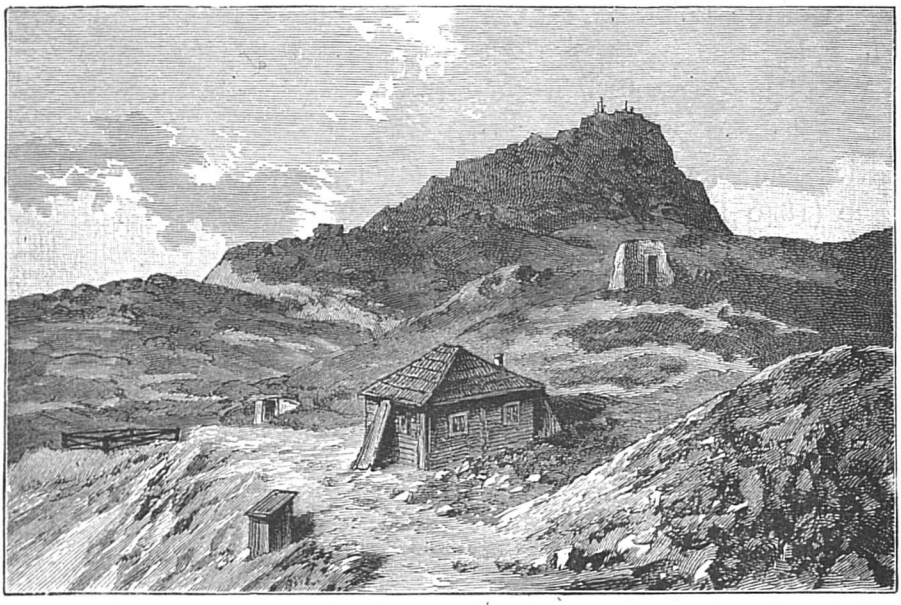
Sandspitze (9189 ft.), the Ganskofel (8990 ft.), the Wildensender Kopf (8961 ft.), the Hohe Kreuzspitze (8824 ft.), and the Hochstadl (8783 ft.). East of this group a carriage-road leads over the Gailberg Saddle (3180 ft.), from Ober-Drauburg (2000 feet) in the valley of the Drave to Kötschach (2261 ft.) in the Gail Valley, following the course of the old Roman road; there is also a carriage-road from Greifenburg (1895 ft.), on the Drave, over the Kreuzer Saddle and the Kreuzberg (3594 ft.), through the Gitsch Valley to Hermagor (1984 ft.), on the Gail. The Reisskofel (7772 ft.) stands between these two passes. South of the Weissensee, a few peaks reach over 6560 feet, such as the Spitzegel (6957 ft.), and the Gradlitzen (6711 ft.), but farther to the east the mountains sink lower, and only rise to any considerable height on the further side of the Windischen Höhe (3614 ft.), which connects Paternion in the valley of the Drave with St. Stephan on the Gail. The Gailthal Alps end with the Dobratsch or Villacher Alp (7107 ft.), south-west of Villach, celebrated for its extensive view, which from the isolated position of the mountain is sometimes considered to be the finest within the Eastern Alps. This mountain is very easy of access; from the mining village of Bleiberg (2925 ft.) at its northern foot, a carriage-road leads to the summit, on which two houses of refuge have been built. On the southern side there are two churches, erected in memory of the fearful landslip of 1348, which shattered ten villages, and turned the valley of the Gail for a long time into a lake.

The Gailthal (*Vallis Julia* of the Romans, Ital. Valle gilia, local Prsile), which separates the two parallel chains of the Carnic Alps, is the largest valley in Carinthia, with the exception of the Drave Valley. It extends in a straight line, as few longitudinal valleys do, for over ninety miles in an east and west direction, only at its lower end passing for a short stretch into a transverse valley with a north-easterly direction. From its

beginning up to Kötschach and Mauthen it is called the Lessach Valley. This valley is little more than a ravine, through which the Gail rushes, the villages and farms lying on the side declivities, chiefly on the sunny side of the valley. The valley widens out beyond Kötschach; the streams which flow into it from either side have so filled it up with silt, that it has in many parts the appearance of a field of alder-trees, where it is not a desolate waste of gravel. Hermagor (2006 ft.) is the chief place in the valley; south of it is the chain of mountains which is celebrated as being the only place where the beautiful *Wulfenia carinthiaca* is found; this chain stands between the Nassfeld and the Göriache Hohe (5537 ft.), and culminates in the Gartnerkofel (7184 ft.). The lowest part of the Gail Valley leads round the group of the Dobratsch; it is still obstructed, and made boggy by the *débris* from the great landslip.

5. The KARAWANKAS are bounded on the west by the Gailitz Valley downwards from Unter-Tarvis, and by the Gail Valley as far as its mouth, on the north by the Drave from Villach to Unter-Drauburg, on the east by the Misslingbach, and on the south by the pass which leads from St. Leonhard in the Missling Valley into the valley of the Packbach, by the latter valley, the valley of the Velunabach, the pass at St. Veit, the valley of the Javoriabach and the Cernibach, the Koprein Valley from Schwarzenbach to its upper end, the Kopreiner Saddle, the Loppein Valley, the valley of the Vellach from Eisenkappel upwards, the Seeberger Saddle, the Kanker Valley, the Save Valley from Krainburg to Wurzen, and by the saddle of Ratschach to Unter-Tarvis. They form the boundary between Carinthia and Carniola, and are divided between these two provinces, reaching on the extreme east also into Lower Styria; their area is nearly 778 square miles. The Karawankas, which form the eastern continuation of the Carnic Alps, are the narrowest of the Alpine chains, and consist of

a long, bare, unbroken ridge, which descends steeply towards the valley of the Drave on the north, and has consequently a far more imposing appearance from that side than from the south. Its wild jagged masses of rock are tinged with a pleasant reddish colour which is not seen elsewhere in the Alps. A high road crosses their midst, leading over the Loibl Pass (4492 ft.) near the Loibl Berg (5646 ft.). The road begins at



Tourist's Hut on the Hoch Obir.

Klagenfurt, and runs directly south; it crosses the Drave at Hollenburg, then turns into the Loibl Valley, mounts to the top of the Klein Loibl (2383 ft.), descends in a zig-zag, and passing over the "Devil's Bridge," crosses the Bodenbach, which descends in a torrent through a wild ravine, then winds up to the top of the pass. The Loibl road was opened in 1728, under Charles VI. The highest part of the joch was originally blasted into a tunnel, but the arch fell in, so that the passage now forms a cutting about nine feet deep. Of

the handsome entrance, only the two side pillars, with their inscriptions, remain. The road descends in seven turns to Neumarkt (1681 ft.) on the Feistriss, and Krainburg (1162 ft.) on the Save. The Loibl road was formerly most important, as it formed the connection between Klagenfurt and Laibach, but since the opening of the southern railway it has become almost deserted. The Velki Stol or Stou Vrch (Stuhlberg, 7344 ft.), the culminating peak of the Karawankas, stands west of the Loibl. West of this point the crest sinks considerably, but rises again in the Grossen Mittagskogel to 7033 feet. A road leads over the western part of the Karawankas by the Pass "die Wurzen" (3511 ft.) from Wurzen on the Save to Riegersdorf in the Gail Valley. The lovely lake, the Faakersee (1840 ft.), lies in a lower range, north of the Mittagskogel. East of the Loibl the Koschuta range begins with the Koschuta (7004 ft.), and extends to the Seeberg (3993 ft.). A road passes over the latter, leading out of the Vellacher Valley into the Kanker Valley. One branch of the Koschuta runs out southward to the Storschitz (Storzic, 6997 ft.), and another northward to the Hoch Obir (7023 ft.), which affords a fine extensive view. The Ovčeva (6329 ft.) stands east of the Seeberg. The rugged, isolated peak of the Petzen (6934 ft.), to the north-east, is still higher. The Ursulaberg (5563 ft.) above Windischgrätz (1341 ft.) in the Missling Valley ends the chain of the Karawankas.

6. The BACHERGEBIRGE or BACHER, a broad stock of granite resting upon gneiss, is bounded on the east by the Karawankas; on the north it reaches as far as the Drave between Unter-Drauburg and Marburg; the Misslingbach as far as St. Leonhard, then the line from there to the source of the Drave form the western boundary, the southern boundary is formed by the Drave; the eastern foot of the range stands in the Pettauer Feld. It is entirely in Styria, and covers an area of 484 square miles. It is a constituent of the Central Alps, from which it is cut off by the

Drave, and forms a little mountain region of its own, having nothing in common, as regards construction, with the neighbouring Karawankas. The richest vineyards of Styria surround its northern, eastern, and southern base, where the wine-growing towns of Pikerndorf, Maria Rast, Radisell, Rittersberg, Vinarje, and Gonobitz lie. Higher up, the mountains are covered with dark forests. They do not reach anywhere above a medium height, the highest point being the Cerni Vrch (Schwarzer Berg, 5078 ft.), beside which stand the Velka Kappa (5061 ft.) and the Bacherberg (4411 ft.).

There remains to be considered that great valley furrow which separates the southern from the central zone of the Alps. This is formed by the largest longitudinal valley of the Alps, which is actually composed of two river valleys, that of the Rienz running westward, and that of the Drave running eastward. In Tyrol both the valleys together, from Mühlbach above Brixen to Lienz, are called the Puster Valley. As the Upper and Lower Wipp Valleys on either side of the Brenner (4466 ft.) are separated by the saddle of that range, so are the Upper and Lower Puster Valley, (Rienz and Drave Valleys) separated by the Toblacher Feld (3949 ft.); the latter, however, though of considerable height, has the appearance of a valley, being dominated by high mountains on the north and south. From Mühlbach to Marburg the valley of the Rienz and Drave is 186 miles long, and to the junction of the Drave and the Mur 280 miles, while the Inn Valley from the source to Kufstein measures only 155 miles. The valley of the Drave, in consequence of its great extent and its accessibility, forms a great artery of traffic, and was the main road by which the eastern nations, such as the Huns, the Sclavs, and afterwards the Turks, penetrated the Alp country. The Drave rises below the Innichner Eck (6255 ft.), at a short distance from the Toblacher Feld, and is there called the Drag or Droag. Its stream is soon increased by the waters of the Sextenerbach,

above Innichen (3823 ft.), where the Duke Tassilo founded an abbey in 770, in the hope of establishing permanent peace among the neighbouring Sclavs by the spread of Christianity. The Drave flows north-east as far as Lienz (2386 ft.), a primitive little town, on the site of the *Loncium* of the Romans. The section which follows may rather be considered as the continuation of the Defferegggen and Isel Valley; a short transverse valley opening out at Sachsenburg (1810 ft.) converts the Möll Valley, which has asouth-easterly direction, into another section of the Drave Valley. At Upper Drauburg (2000 ft.) the Drave enters Carinthia, through which it flows as far as Lower Drauburg. From Upper Drauburg to Sachsenburg the valley is called the Upper Valley of the Drave, and from there to Villach, the Lower Valley of the Drave; from Villach to the mouth of the Gurk it is called the Rosen Valley, and the last reach in Carinthia as far as Lower Drauburg, the Jaun Valley. Villach (1665 ft.) is the principal Carinthian town in the valley of the Drave. It is a cheerful and populous old town, where formerly the Roman *Villa ad aquas* stood. In the middle ages it was a flourishing centre of German and Italian commerce, being situated at the most important junction of the great main roads between the Danube and the Adriatic, which run from Vienna to Venice, through Bruck, Judenburg, St. Veit, Villach, and Udine. Past Villach the valley of the Drave spreads into a plain about 1480 feet high, the middle of which is occupied by a chain of hills. At Lower Drauburg the mountains on either side again approach each other; so that the Valley as far as Marburg (881 ft.), has more of a ravine character. Marburg, the second town of Styria, is picturesquely situated on the left bank of the Drave, at the foot of the Posruck. From this place, proceeding down the river, the flats begin, which may be considered as spurs of the Hungarian plain.

7. The SANTHALER or STEINER ALPS, also called the

SULZBACHER ALPS, are bounded on the west by the valley of the Kanker from Krainburg to the source of the river, by the Seeberger Saddle, and the Vellach Valley as far as Eisenkappel, on the north by the Loppein Valley, the Kopreiner Saddle, the Koprein Valley as far as Schwarzenbach, the Cernibach, the Javoriabach, and the pass from St. Veit to Schönstein, on the east by the Pack from Schönstein to its mouth, and thence by the San past Cilli to its confluence with the Save; on the south they slope down between Krainburg and Steinbrück to the valley of the Save. The area of the group, 646 square miles, is divided between Carinthia (north-west), Carniola (south-west), and Styria (east). In the Santhaler Alps the rocks of the Gailthal series rise in huge undulations; a continuous covering of triassic limestone formerly lay above it, but being now broken up and displaced, or destroyed by erosion, it has been preserved only in fragments on the top of the northern summits on the Styrian boundary towards Carinthia, while on the south-west and south of the Upper Santhal towards Carniola it forms a connected district, on the west, south, and south-east side of which the underlying strata of the Gailthal beds appear. The Santhaler Alps project farther to the south-east than any other groups of the Alps proper, and resemble the dolomite mountains of South Tyrol in character, and in their wealth of natural beauty. The highest point is the Grintovc or Grintouz (8393 ft.), situated on the threefold boundary of Carinthia, Carnolia, and Styria. Its summit is covered with loose white stones, and its crevices bear snow even in summer; it affords a magnificent view, including the whole of the Alpine country from Salzburg to the plains of Croatia, and from the jagged points of the Triglav group to the Styrian hill country. The Skuta, or Rinka (8298 ft.), the next peak to the east, has a similar view, but the immediate surroundings are still grander. The Kanker Kotschna (8334 ft.) is situated in the west of the group, and farther to the east is the peak of the Ojstrica (7709 ft.). The

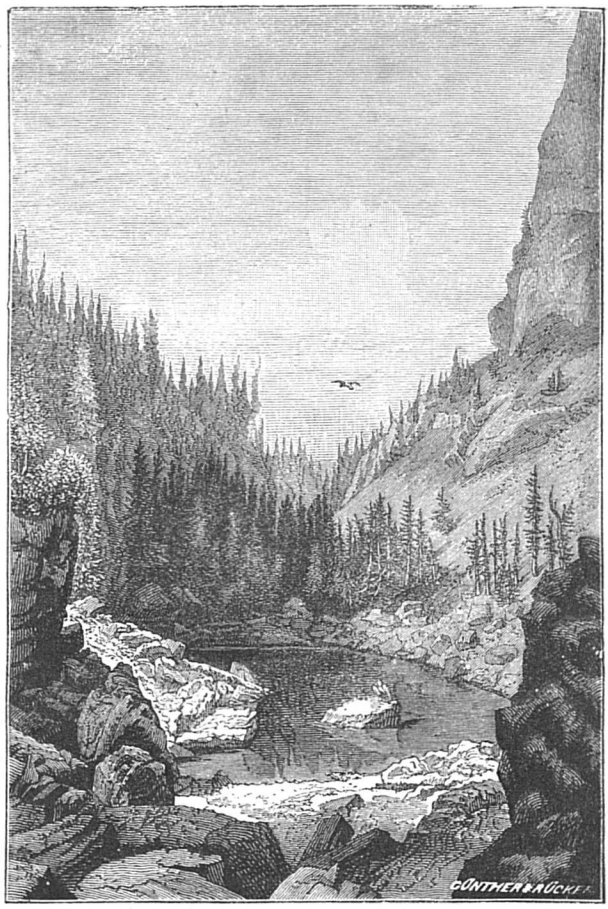
chain which runs out from this block between the Feistriss and the San is considerably lower; the deep saddle at Trojana (1997 ft.) is crossed by a road leading from Laibach to Cilli. The end of this range between the San and the Save, is unusually rich in coal, which is obtained at Trifail in extensive open workings, and at Sagor, is famous for the quantity of fossil plants found in it.

The San rises at the north side of the Rinka in the beautiful cauldron valley of the Logar, at the end of which it forms the Rinka Fall, a fine cascade nearly 400 feet high. The last village in the San Valley is Sulzbach (2132 ft.), east of which rises the Raducha (6773 ft.), the last peak of the chain on the left bank of the San. The valley lower down is rich in beauty. Between Frasslau and Cilli it expands into a broad basin, but in the lowest reach, where it turns southward, it again contracts, becoming most picturesque, and in some parts extremely wild. The warm springs of Tüffer (920 feet) and Römerbad (691 ft.) are situated here. A branch of the Vienna and Trieste Railway passes through the Lower San Valley, and crosses the Drave at Marburg, then winds round the eastern foot of the Bachergebirge, from there crosses a chain of hills into the Drave Valley, and between Pöltschach and Ponigl crosses the watershed between the Drave and the San. It reaches the Save at Steinbrück, and runs alongside of it to Laibach.

8. The JULIAN ALPS, or the TRIGLAV GROUP, are bounded on the west by the Fella from where it enters the plain up to Pontebba, on the north and east by the Canal Valley, the saddle of Ratschach, and the upper valley of the Save as far as the mouth of the Zayer, and by the Laibach plain, on the south by the Laibach up to Ober-Laibach, then by a line drawn northwest to the sources of the Zayer, by the Zayer to the point where the valley changes its direction from north to east, then by the Idria till it discharges its waters into the Isonzo, and by the Isonzo nearly to Görz; on the south-west the boundary-line

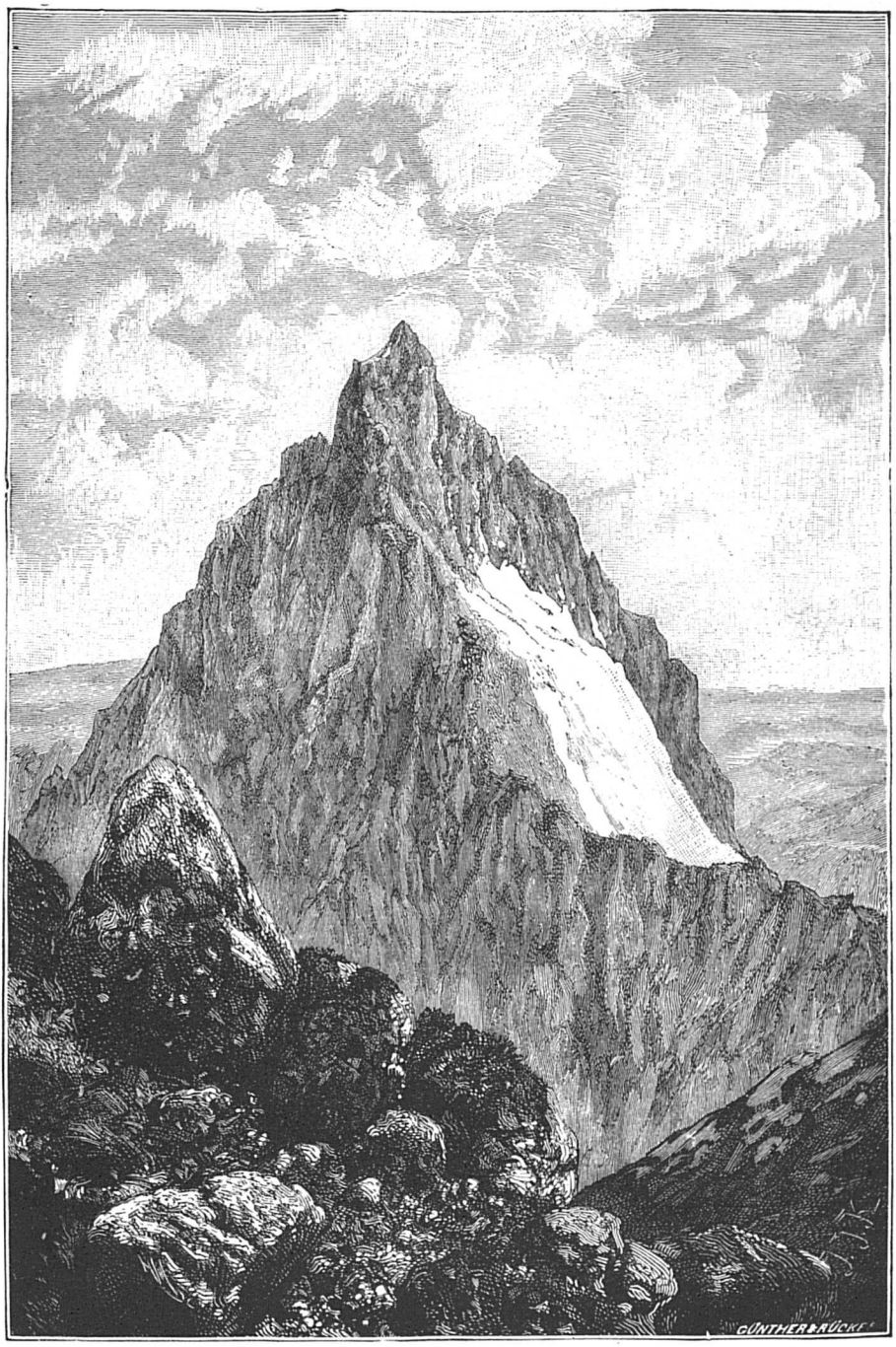
goes through Görz (281 ft.), Cividale (472 ft.), and Gemona (908 ft.) into the Italian plain. A small portion of the Julian Alps, in the north-west, belongs to Carinthia, the west belongs to Venetia, the middle to Görz-Gradisca, the north-east and east to Carniola. The area of this group measures 1076 square miles. Dachstein and dolomite are the prevailing rocks; the bold, picturesque masses of the range near Flitsch are composed of them, as are also the Matajur, Mangart, Krn, and the Triglav, but on the east of the latter they are covered with liassic limestone. Porphyry appears at the north-west end of the chain, at Raibl. The sources of the Fella, the Isonzo, and the Save lie in the Triglav Group. The valley of the first of these has already been described. The Isonzo rises in a cauldron on the western side of the Triglav, and flows south-west and west, through the Trenta Valley, till it enters the arid plain, the Flitscher Boden. At Flitsch (Ital. Pless., 1469 ft.), the road coming from the north, over the Predil Pass (3811 ft.) enters the valley of the Isonzo. This road begins at Tarvis, and going southward, ascends to Raibl (2925 ft.), whence it soon reaches the Raibler Lake (3246 ft.), which is beautifully situated. The Raibler Alps rise to the west, containing the peaks of the Wischberg (8754 ft.), the Monte Cimone (7810 ft.), and the Mittagkofel (6859 ft.). The Luschariberg (Svete Višarge, 5878 ft.), a less elevated peak, has a chapel, which is visited by a greater number of pilgrims than any other in Carinthia. Some of the peaks of the Canin Group are seen south of the Raibler Alps; they are separated from the latter by the Raccolana Valley, and culminate in the snow-capped peak of Monte Canin (8469 ft.). The horns of the Mangart (8784 ft.) rise east of the Raibler Lake, and near it is the Jalouz (8708 ft.). The Predil Pass, which marks the boundary between Carinthia and the coast-lands, crosses between the masses of Monte Canin and the Mangart. Beyond this pass a fortress covers the road, and a fine monument stands to the memory of

Captain Hermann and his brave soldiers, who fell here on May 18th, 1809, while heroically defending the place against the French. The road then enters the oft-contested defile, the Flitscher Klause, over six miles long, which ends above Flitsch. The Isonzo Valley takes a south-easterly direction, at the




The Schwarze See on the Triglav.

southern foot of Monte Canin. The town of Karfreit (Ital. Carparetto, local Kobarid, 1013 ft.) lies in this part, between the Krn (7367 ft.), a spur of the Triglav, on the east, Monte Maggiore (5303 ft.) on the north-west, and the Matajur (5386 ft.)




The Summit of the Triglav.

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on the south. A road leads from Karfreit, over the saddle of Robič (839 ft.), to Cividale (472 ft.), in the valley of the Natisone. The Isonzo maintains the south-easterly direction up to the mouth of the Idria then turning to the west, it enters the plain just above Görz. A road leads eastward from the junction of roads at Tarvis, into the Save Valley, passing over the Weissenfels (in the neighbourhood of the two Weissenfelser, or Mangart Lakes, 3059 ft.) and the saddle of Ratschach (2846 ft.), which forms the watershed between the Gail and the Save. The Save, which is distinguished by its transparent bluish-green water, rises from two sources. The Wurzener Save flows out of the Little Wurzener Lake, on the northern side of the Mangart block, and, passing through the wild Planitza Valley, turns eastward above Wurzen, and afterwards south-eastward, joining the Wocheiner Save or Savica above Radmannsdorf and from there is called simply Save or Sau. The second head stream comes from the wild, romantic Wocheiner Lake (1729 ft.), on the south of the Triglav, and flows through the picturesque valley of the Wochein in an easterly direction. Between the two streams, near their confluence, lies the lovely Veldes Lake (1566 ft.), the waters of which are carried off by the Savica. Veldes (1643 ft.), a well-known health-resort, stands on its northern shore.

The highest mountain in the Julian Alps is the Triglav or Terglou, which stands south-east of the source of the Wurzener Save; its three sugar-loaf peaks rise out of the snow to a height of 9394 feet. The middle peak is ascended with great difficulty over the Little Triglav (8986 ft.); on its northern side is a small snow-field, which is the most south-easterly one in the Alps. The view obtained from this peak, far over the Adriatic Sea, is one of the finest in the whole of the Alps. The seven small lakes of the Triglav, the deepest of which is the Schwarze See, lie among huge rocks, snow-fields, and boulders, or sometimes lower down in the shadow of dark woods. The huge

Triglav mass forms an important division where the Alps and the Karst range meet. The waters of three rivers flow from it, the Drave (Gailitz), the Isonzo, and the Save, it also separates three races, and three languages, the German, the Sclav, and the Italian.

### (*d*) The Eastern Outliers of the Alps.

Mountain chains and hilly country extend between the Danube on the north and east, and the Save on the south, being spread out in the form of a fan. It is true that they remain throughout at an elevation far below that of the Lower Alps, and are consequently devoid of the Alpine characteristics, but they are connected both physically and geologically with the outermost groups of the Eastern Alps, and are therefore treated as outliers of them. The Leithagebirge and the Bakony Forest stretch from south-west to north-east, the Croatian-Slavonian mountains from north-west to south-east; the mountains and hills lying between have no clearly defined general direction. These chains almost exclusively stand on Hungarian or Croatian soil.

1. The Rosalien and Leitha mountains form the north-eastern extension of the Wechsel Group, and contain part of the boundary between Lower Austria and Hungary; the Leitha flows at the north-western foot of the range, the Neusiedler Lake spreads itself at the eastern foot. The Rosalien range immediately adjoins the Wechsel, its eastern portion being also called the Bucklige Welt, and its western part the Grosse Kaiserwald; it is a gently undulating wooded chain, bearing on its highest point the Rosalien chapel (2446 ft.). The range is continued on the further side of a deep depression at Wiener Neustadt, by the Leithagebirge, which culminates in the Sonnberg (1577 ft.), north-west of Eisenstadt. The wooded heights of this range, which is composed of gneiss and limestone, form a wall-like connection between the Alps and the Carpathians. The Hainburger Group between the Leitha and the Danube looks like an outpost of the latter range.

2. The STYRIAN HILL-COUNTRY, in Styria and the part of Hungary which bounds it, is connected with the Raabthaler Alps, and fills the space between the Wechsel Group and the Mur as far eastward as the middle of the Raab, and reaches the height of 986 feet. The Geschriebenstein at Güns, the first outpost of the Alps rises to the height of nearly 2900 feet.

3. The BAKONY FOREST, which is entirely in Hungary, stands with its thick woods and rounded peaks, between the Marczal, the Zala, Lake Balaton, and the Danube between Almas and Buda-Pesth. The Bakony Forest proper has for its highest peak the Blauen Berg or Bakony-hegy (2338 ft.), north-west of Veszprim ; the Papodhegy (2123 ft.), the Kabhegy (1970 ft.) to the south-west, and the Köreshegy (1891 ft.), north-east of Veszprim are lower peaks of this range. The great Lake Balaton (Plattensee 347 feet above the sea, 266 square miles in extent), called the Hungarian sea, lies south of the Bakony Forest. The Vertesgebirge joins the Bakony Forest on the north-east, and contains the peak of the Körtvelyes (1587 ft.), west of Buda-Pesth, and the Csoka (1573 ft.), south-west of the Körtvelyes. Farther to the north-east are the Pilisgebirge, containing the Pilis (2476 ft.), and the Gerecs (2066 ft.), which together with the Neograder Gebirge of the Carpathians, which lie opposite, enclose the Danube Gorge of Gran-Waizen. The Ofner Weingebirge (culminating peak the Johannisberg, 2739 ft.), is connected with this range on the south ; the Blocksberg at Ofen is 770 feet high.

4. The PANNONIAN or LOWER HUNGARIAN HILL-COUNTRY is a continuation of the Styrian Hill-country, running along the left bank of the Mur and Drave, south of the Raab, and, filling the triangle between the Drave, the Danube, and Lake Balaton. The north-western part, nearly as far east as Zala, is called the Sümegher Plateau ; the Somogyer Plateau, extends between Lake Balaton and the Upper Kapos. The mountains of Baranya or the Fünf Kirchner Group between the Drave, the

Danube, and the Kapos, is highest in the peak of the Mecsekgebirge (2200 ft.), north of Fünfkirchen.

5. The MOUNTAIN COUNTRY of CILLI is separated from the Santhaler Alps, by the San and the Packbach, and is bounded on the south by the Save, on the east by the Sotla, and on the north by the Upper Drave. Its entire area of 268 miles belongs to Lower Styria. In the western part it presents the characteristics of the secondary mountains, but in the east it gradually sinks into a low mountain range, and hilly land. It takes its name from the old town of Cilli (791 ft.), on the San, which was founded by the Roman Emperor Claudius as the *Colonia Claudia Celeja*. The culminating peak is the Wachberg (3364 ft.), south-east of Cilli; the Wotsch (3209 ft.) is in the north-east. The Donatiberg (2899 ft.) is also in this part; and at its foot stands the town of Rohitsch, in the neighbourhood of which are the medicinal baths of the same name.

6. The CROATIAN-SSLAVONIAN mountains begin at the Styrian and Croatian boundary, and extend across the Croatian Mesopotamia, between the Drave, the Danube and the Save, eastward as far as Slankamen, opposite the mouth of the Theiss. They are separated from the southern part of the mountains of Cilli by the Sotla or Sutla, but are connected with the most northerly part. The Matzelgebirge (Croat. Macelj gora), 1704 feet high, joins this part, and the Topliča gora (986 ft)., is an eastern extension of the latter range. The Kostelska gora extends southward from the Matzelgebirge to the Save, and culminates in the Kuna gora (1765 ft.). The Ivančica is connected with the Matzelgebirge at the source of the Bednja; its highest peak of the same name reaches a height of 3482 feet. A southern collateral branch connects this with the Zagrebačka gora, which ends at the mouth of the Krapina, and culminates in the Sleme (3396 ft.). From this peak a delightful view is obtained into the Zagorje, the "Croatian Switzerland," north of the Krapina. At the source of the

Lonja, a saddle separates the Ivančica from the Kalnik (2110 ft.), from which again the Bilo gora, containing the Gradec (1144 ft.), branches off, at the source of the Koprivnica. The chains of the Crni vrh (2836 ft.), and Pakračka gora (Kik, 2351 ft.), which extend west-south-west, are connected with the south-eastern end of the Bilo gora. The Sujnik, containing the Brezovo polje (3227 ft.), and running in the same direction, is joined to the Pakračka gora further to the south, by means of a saddle. South-east of the Bilo gora, the Moslavačka gora forms on both sides of the Čazma an entirely separate block, which is composed mainly of granite enclosed in tertiary formations. The peak of the Hunka (1607 ft.) stands east of the Čazma.

The Crni vrh, the Pakračka gora and the Sujnik form the central group in the mountains of the Croatian Mesopotamia. Its eastern spurs are divided into northern and southern by the Orljava. The southern spur, the Pozeška gora, which culminates in the Maksimov hrast (2019 ft.), is a continuation of the Sujnik, and ends at the lower Orljava. The northern spur, the Papuk, begins at the source of the Bučinska, culminates in a peak of the same name, 3130 feet high, and is continued in the Krndija (Kapavac 2577 ft.). The latter is connected by a saddle with the Dilj gora on the south, which reaches a height of 1495 feet in the peak of the Prijedolje. It ends on the east at the Jošava torrent which empties itself into the Božut. Here the range terminates, and the marshy land is nowhere higher than 330 feet above the sea, until some hills appear south of Bukovar. These are the beginning of the Fruška gora, the most easterly group of the Croatian and Sclavonian mountains. They are situated on the right bank of the Danube, and descend steeply on the river side, and extend in a straight line as far as Slankamen, where the last hills disappear. The peaks, which are overgrown with woods, still exceed the height of 1600 feet, the Crni čot being 1762 feet high, and the Veliki brijeg 1687 feet.

Throughout the mountains of the Croatian Mesopotamia, passes, sometimes narrow, sometimes broad, are found between the different spurs, and are remarkable for their luxuriant vegetation. The flanks have a steeper slope towards the north than towards the south; the latter side is richer in rivers, and in its flora, than the northern side, consequently the left branch of the Save (the Posavina), is more thickly populated than the right bank of the Drave (the Podravina.) The great fertile plain between the Fruška gora and the Save is named from the former Roman town of *Syrmium*, now Syrmien (Croat. Sriem).

## CHAPTER IX.

### THE ALPINE VALLEYS, AND VALLEY SYSTEMS.

It must be evident that, as far as man is concerned, the valleys are of far greater importance than the mountains. Even among the hilly-lands and low mountains, the agricultural value of the valleys is as a rule greater than that of the hills; in the Alps and high mountains it is almost exclusively the valleys which are available for husbandry. Only in a few favoured sunny situations, where the slope is gradual, can the lower part of the flanks or terraces of the mountains be used for cultivation to any great extent. It is in the valleys that the fertile alluvium, the product of weathering, is collected, when it has been carried down from the mountains by torrents, or by rain and wind.

For every 560 feet of increased height in the Alps the mean temperature decreases 1° Cent., whence it is easy to realize at what a short distance above the valley the warmth becomes insufficient to make the cultivation of ordinary crops profitable.

It is in the valleys of the high mountains, therefore, that man has made his abode,—there are the villages and towns, through them high-roads and railways have been made, from them the various districts take their names, they determine dialects, costume, manners, customs, arts and industries.

In every valley we distinguish the flanks or walls of the valley, and the valley-bottom. The former are nothing more nor less than the slopes of the ridge which enclose the valley, the latter is the lowest part of the valley lying between the two enclosing

slopes, horizontal or nearly so in relation to the sides, and almost always containing the bed of a stream of greater or less depth. The valley-bottom may be of considerable breadth or may contract to a mere line. Among the high mountains the second form is most frequently found, although here also the bottom often opens out to a considerable breadth. The valleys of the Reuss and the Ötz offer examples of this kind, the former having a breadth of three-quarters of a mile at Andermatt, and the latter a breadth of over two miles. It may often be seen that the valley-bottoms of different periods have been deposited one above another in the form of terraces; these are usually distinguished as coast terraces. They are chiefly found overlaid with loose stones, and situated in the wide part of a valley. The origin of these may be attributed partly to the much larger volume of water contained in the river at an earlier period, and partly to the firmness of the lower beds of rock. A beautiful example of coast terraces is shown at St. Egyd in the valley of the Hohenberger Traisen in the Lower Austrian Alps.

If we observe the valleys transversely, in profile, they will be seen to assume various forms, to which different names are given; for instance, a narrow, shallow rift made by the rain-water is called a gully (German, Siefen, Regenrisse, or Rocheln). To more important depressions and openings, different names are given in different parts of the Alps, which have no exact equivalent in English.

A narrow valley enclosed on both sides by the steep flanks of mountains is a ravine, or, when the rocks are still steeper, and the valley narrower, a gorge; as, for example, the Tamina Gorge at Pfäfers.

Parts of the valley which contract into ravines or gorges, only to open out again to a broad basin soon after, are frequently called passes, particularly if they are fortified, as in the case of Pass Lueg, Pass Werfen, &c. This form is usually found where there is an important fall in the valley level, and consequently a considerable disturbance of its waters.

The Ravine at Hochfinstermünz, in the Valley of the Inn.

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When the sides of the valley fall back so far that either a circular or oblong widening of the valley results, a valley-basin is formed. This form frequently occurs at the junction of several valleys; many beautiful, extensive valley-basins occur in the high mountains, which are usually closed in at their lower end, and are occasionally marshy in places; they are enclosed by high rocks, and are formed in such a manner as to leave no doubt that they were formerly the bottoms of lake-basins. When a valley-basin is very large, the bottom becomes a valley plain.

In connection with the valley-basin we may also consider the troughs and cauldron valleys. Troughs are broad hollows on the slopes of the mountains. In the higher mountains the name Kar or Kor is sometimes given to those troughs with which the valleys frequently begin immediately below the crest. This designation is used principally in the northern limestone zone of the Eastern Alps. These "Kars" are enclosed by rocks, except on the side towards the valley, and are often of considerable extent. As they are usually moister than the convex parts of the mountains, they contain the best Alpine pastures, but are often covered down to the very bottom with rubbish, and in the higher parts with snow and ice.

Cirques or cauldrons are of larger dimensions; they occur among the central masses of the Alps, and are not entirely absent in the limestone zones. These valleys are circular and are enclosed by steep rocks, suggesting the form of an amphitheatre. The origin of glaciers is dependent upon the presence of these cauldrons in the highest regions. The eastern part of Mont Blanc offers the most interesting examples of the cirque formation, no less than four of these great hollows meeting together there at one point, the Aiguille de Triolet. The masses of snow stored in them feed four ice streams, of which the Glacier de Talèfre and the Glacier d'Argentière flow to the north-west, and the Glacier de Triolet and the Glacier du Mont

Dolent to the south-east. The greatest length of this trough, as far as it is covered with snow, that is from the foot of one of the enclosing walls to the other, is two and three-quarter miles, and its breadth nearly one and three-quarter miles; the depth from the summit of the Aiguille Verte to the deepest part of the depression is 4160 feet. The great snow-filled trough of the Aletsch Glacier is still larger, having a length of over six and a half miles from the Lötschenlücke to the Grünhorn, and a breadth of over four miles from the Jungfrau Saddle to the Faulberg. These cirques sometimes reach far down, and then generally form the end of a narrow valley. Such a cirque may be found on Monte Rosa, at the back of the Anzasca Valley, the sides of which ascend perpendicularly all round to a height of 6560 feet from the bed of the trough, which itself lies at a height of 5248 feet. A still more magnificent example of this formation is found south-east of Bourg d'Oisans, at the foot of the Grand Pelvoux. These cirques are, in most cases, thought to be the result of the fall of masses of rock. Another kind of valley is found on the plateau of limestone blocks; like the "Dolinen" of the Karst they are due to the liability of the limestone to erosion; the caverns formed by the washing away of the ground from below, sometimes attain such an extent that the upper covering of the cavern falls in and a cauldron-shaped valley is formed.

The characteristics and varieties of form in the longitudinal contour of the valley must now be considered. These are the origin or head of the valley, the fall of the valley, the height of the valley, and the direction of the valley. The head of the valley is the highest part and the furthest removed from its mouth. It lies at the foot of what Sonklar calls the back-slope (Hintergehänge) of the valley, which closes it at its upper end. The form of the back-slope is very varied; sometimes it is a narrow channel which occurs where two defiles unite at a very sharp angle, and, as it were, cover the back-slope, and sometimes it is simply a trough. In many other cases, and especially

when two collateral crests run out from the main crest at right angles, the back-slope is a triangular plain of varying breadth, cut up into troughs and runnels, usually depressed in the middle and associated with a correspondingly deep saddle on the main crest. In the case of the cirque valleys mentioned above, the back-slope sometimes has the form of a semicircle with compact walls of steep or vertical rocks, or is cut up into a large number of radiating channels; when the slope is steep, this form suggests an amphitheatre, and when there are glaciers on the crest and in the high troughs, the effect is exceedingly fine.

The fall of the valley also presents great variety, being in some valleys very slight, and in others very important. When it is slight it is fairly uniform throughout; when it is great, the valley bottom descends by bounds and leaps; in some places the greatest fall is in the higher portions of the valley, in others in the lower parts. If a straight line is drawn from the head of the valley to its mouth, the angle formed by that line and the horizon gives the mean fall of the valley. Both the amount of fall and its distribution are of great importance. Inundations among the mountains are for the most part the result of a rapid fall. The general fall is not distributed in the same manner throughout the length of every valley. Of two valleys, in one of which the fall is greatest in the upper part, and in the other of which it is greatest in the lower part, the former will be comparatively cold and unsuitable for cultivation, but in the latter the contrary will be the case. Generally speaking, the longer valleys have a slight fall, and the shorter ones a rapid fall. The distribution of the fall in different sections of the valley appears to be dependent partly upon the length of the valley, and partly on the structure of the ground through which the valley furrow is cut. Long valleys have usually a uniform fall, short valleys a diversified fall. There are, however, striking exceptions. The Langtauferer and Pitz Valleys, the Stubai, Ziller, Gurk and Lavant Valleys, all comparatively short, have a remarkably

uniform fall. In all valleys, without exception, the fall is greatest near the back-slope; further down the form depends mainly upon the direction of strike of the different beds of rock. If this direction coincides with the valley-bottom, the latter generally follows the same bed, or at least a member of the same formation. The action of erosion will therefore be the same throughout, and the fall of the valley will be uniform; but if the rocks on the surface are cut off either obliquely or vertically from the direction of the valley, the valley bottom must pass on to other beds of rock, which from their different power of withstanding erosion are worn away sometimes more slowly, sometimes faster, the fall consequently becoming unequal, and at times even proceeding in great leaps. Thus the terraces and steps are formed, which in their turn are the cause of rapids and waterfalls. The transverse valleys of the Alps present some remarkable examples of step formation.

The mean height of a valley is the height that it would have if, without changing the superficial contents of the valley bottom, the longitudinal section were changed into a horizontal line. The value of this is obtained by ascertaining the actual height at a certain number of points distributed at equal distances through the length of the valley, and taking the average.

The length of valleys is also various. Valleys which run parallel with the longitudinal axes of extensive mountain chains are often very large; those that run in a transverse direction are, on the contrary, of inconsiderable length. The longest valley in the Alps, and indeed in Europe, is that of the Rhone, which up to the point where it enters the Plain of Lyons is 230 miles long; next to this come the Valley of the Drave as far as Warasdin, 207 miles; the Valley of the Inn as far as Rosenheim, 185 miles; the Valley of the Save as far as Agram, 145 miles; and the Valley of the Rhine as far as Bregenz, 115 miles.

The important division of the valleys into longitudinal and transverse, depends upon the direction which they take in rela-

tion to the main axis of the range. The longitudinal or parallel valleys run, as a rule, parallel with the main axis, and are distinguished by having a slight fall distributed through a great length; the transverse or cross-valleys, cut through the range in a direction opposite to that of the main axis, and are usually short and steep; the former run between prominent chains of mountains, the latter break through one or more of them. The

Part of the Zillerthal near Dornauberg.

valleys of the Rhone, the Vorder-Rhine, the Inn, the Salzach, and the Drave may be given as examples of very characteristic longitudinal valleys; the valleys of the Reuss, the Tessin (Ticino), the Ötz, and the Ziller are examples of transverse valleys. The slopes of the mountains which enclose longitudinal valleys are less precipitous than in the transverse valleys, the inclination of the valley is less, the valley bottom is more level, and the stream, which is usually a large river, winds through the bed of the valley with many turns and often with a moderate

fall. The short, steep transverse valleys are enclosed by precipitous rocks; the streams rush down the mountains, often leaping over great ledges of rock in a cascade, or falling in light spray. The torrents sweep all obstacles from their path with invincible power, tearing away masses of rock, and carrying them along, heaping up mountains of rubbish and boulders, and making the passage of the valleys difficult.

Often two or more longitudinal valleys lie along the same straight line, in such a way that, on a map, one appears to be the continuation of another. If the heads of the two valleys are near each other, they are usually connected by a low saddle. Thus the valleys of the Rhone, the Urser and the Rhine from Martigny to Chur run almost in a straight line, and are connected with each other by the comparatively low saddles of the Furca Pass and the Oberalp Pass.

In addition to longitudinal and transverse valleys, Von Sonklar also distinguishes diagonal valleys, that is, valleys which form a sharp angle with the range of mountains, as is the case with the Fleimser Valley in Tyrol, the Valley of Mittendorf between Aussee and the Enns, the Eisenerzer and Vordernberger Valley at Leoben, the Canal Valley between Tarvis and Pontafel, and the Val Leventina between Airolo and Biasca. A double-sided diagonal valley is formed when the saddle penetrates deeply into the mountain block, as in the Liesing-Palten Valley between the Enns and the Mur at Rottenmann.

With regard to their relation to each other, valleys are distinguished as main valleys and collateral valleys, this description expressing much the same idea as that of main streams and tributary streams. The main valley is the larger and longer, or is that which under almost the same conditions does not change its position at the point where it unites with the tributary valley. Beyond that point the collateral valley, like the tributary stream, loses its name.

The main valleys are usually the seat of culture and of manu-

facture ; the collateral valleys, which are often narrow and rocky, are only made available for traffic with great difficulty, and have only here and there a sparse population. These collateral valleys also have their tributary valleys, but they are of little use for human habitation.

The main valleys with their collateral tributary valleys, taken altogether, form a valley system.

The steep southern slope of the Alps, with the exception of the Etsch district, exhibits no very great valley systems, but a considerable number are found on the western, northern, and eastern sides of the Alps ; it should, however, be remarked that the main valleys of the Eastern Alps, which are for the most part uniform, and run out towards the plain, have an entirely different character from the Alpine valley systems of the west and north.

The following sketch of the most important of the Alpine valley systems will also serve to make the reader acquainted with the rivers :—

1. *The Valleys of the Ligurian Coast.*—The valley systems of the smaller rivers which flow into the Ligurian Sea, such as the Arrosia, the Taggia, the Nervia, and the Roja, are unimportant, while the Var, which rises in Mont Pelat, and empties itself west of Nice, presents, with its tributary streams the Vaïre, the Tinée, and the Vésubie, a system with considerable ramifications. The valley system of the Argens, which flows into the Gulf of Fréjus, belongs to the lower mountain and hilly land.

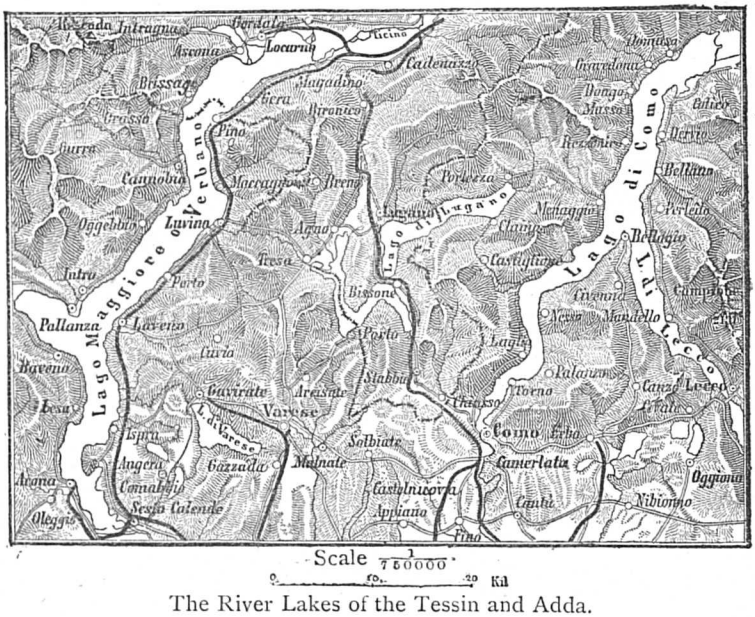
2. *The Valley Systems of the Rhone District.*—The valley of the Rhone is the largest of the Alpine valleys, having a length of 230 miles from its origin to the bend at Lyons. This valley, as well as the main valleys of the Isère and Durance, have a general direction from east to west, but with many turns and windings. The Rhone rises on the western slope of the St. Gothard range below the Furca Pass, flowing out of the beautiful Rhone glacier, west-south-west through the upper part of the Canton Valais, where the glacier streams from the Valais and Bernese Alps flow into it right and left through numerous collateral valleys. The northern collateral valleys are all short and steep; the longest of them is the Lötschen Valley, through which the Lonza flows. Those on the southern side are much longer ; they trend chiefly north and south, and are all forked, such are the Visp Valley, the Einfisch Valley, and the Valley of the Borgne ; only the valley of the Dranse trends chiefly north-west. At Martigny the Rhone turns at a right angle to north-north-west, and there enters the Lower Valais, which opens

out to the Lake of Geneva. At Geneva the Valley of the Arve ends, having originated in the Col de Balme in the valley of Chamounix. The Rhone leaves the lake which it has formed, close to Geneva, then flows between the Alps and Jura with many turns towards the south-south-west, afterwards north-west, and west, and at Lyons leaves behind it the last spurs of the Alps. The main valley of the Isère descends westward from the north-western flank of Mont Iséran in many windings, receiving from the left the important collateral valleys of the Arc and the Drac. The Drôme, the Eygues, and the Ouvèze form shorter valley systems. The valley of the Durance, which rises in Mont Genèvre and enters the plain below Pertuis, has a more southerly direction; the valleys of its tributary streams, the Buech on the right, the Ubaye, Bleone, Asse, and Verdon on the left, are extensive and well developed.

3. *The Valley Systems of the Rhine District.*—The Rhine with its tributary the Aar, and the affluents of the latter, the Reuss and the Limmat, do not unite into one stream until they have passed out of the true Alpine district; they may therefore be considered as four separate valley systems of which the Aar is the most important. This valley system intersects the north-western portion of the Central Alps and its outliers. Of the three head-streams of the Rhine, the Vorder-Rhein has its source in the Toma Lake on the eastern flank of the St. Gothard; its valley extends east-north-east as far as Chur (Coire), but is joined before it reaches that point by the tributary valleys of the Mittel-Rhein (at Dissentis) and the Hinter-Rhein (at Reichenau), both of which come from the Adula Alps. At Chur the valley of the Rhine, receiving on the left the valleys of the Landquart and the Ill, turns northward, till it spreads out into Lake Constance. This lake receives the Bregenzer Ache, which forms a separate valley system in the Vorarlberg Alps. The Rhine leaves the lake by its western end, and shortly afterwards leaves the Alps, which it separates from the German Jura. The sources of the Aar, or Aare, lie in the Oberaarhorn and Lauteraarhorn. It flows first northward through the Hasli Valley, then turns westward, forming the lakes of Brienz and Thun, and receiving on the left the numerous glacier streams from the Bernese Alps; below Berne it receives the Saane, and taking a turn to the north leaves the district of the Alps. Thence it flows in a north-easterly direction through the Swiss plain, receiving the Emmen coming from the Alps, through the Emmen Valley, the Reuss, and the Limmat. The Reuss, which also comes from the St. Gothard, forms the Lake of Lucerne. The Limmat flows out of the Lake of Zürich. In its upper course it is called the Linth, and is carried, by means of a canal, into the Walen Lake, which also receives the Seez. The Walen Lake and Lake of Zürich are connected by the Linth Canal.

4. *The Valley Systems of the Po District.*—The Po rises on the eastern flank of Monteviso, and quickly leaving the mountain, only forms with its upper part a short transverse valley. Its Alpine affluents, the Varaita, Maira, Stura, and Tanaro on the right, the Pelice, Clusone, Dora Riparia, Stura, and Orco on the left, form only small valley systems. The valley of the Dora Baltea, which trends eastward from its sources to Chatillon, and south-eastward from there to the plain at Ivrea, penetrates further into the mountains. The numerous valleys of the streams which flow to the Po from the north penetrate further still into

the range, as for example the valley of the Tessin (Ticino) which rises on the southern side of the St. Gothard block, and forms the Lago Maggiore; among its collateral valleys, the Toce, or Tosa, which flows into the Lago Maggiore, is the most important. The second in size of the lake rivers of the Po district is the Adda, which comes from the Umbrail Group, and flows south-west and west through the Veltlin, into the Lake of Como, which it leaves again by its south-eastern end. The Maira, or Mera, also belongs to the valley system of the Adda; it rises on the Maloja Pass, flows through the Bergell, and empties itself into the Lake of Como. The Valley of the Oglio has its origin on the Corno dei Tre Signori in the Ortler Alps, and has a general direction to the south; it ends at the Lake Iseo, through which the Oglio flows. The neighbouring valley to the east is




The River Lakes of the Tessin and Adda.

that of the Chiese, which comes from Monte Fumo, forms Lake Idro, and enters the plain at Salo. The Mincio is the off-flow of Lake Garda; the affluents of this lake form a valley system with numerous ramifications, the most important valley of which is the Sarca, which originates in the Crozzon di Lares in the Adamello Group.

5. *The Valley Systems of the Etsch District.*—The sources of the Etsch are formed by several small lakes on the Reschen Scheideck. It first flows southward through the Malser, being joined east of Glurns by the longitudinal valley, the Vintschgau, as far as Meran, and both right and left by numerous collateral valleys, among which the most important are the Passeier Valley on the left, and the Ulten Valley on the right. The Etsch has a south-easterly course from Meran to Botzen, and a south-south-westerly course from there till it leaves the mountains, when its lower course begins at Verona. The Valley of the Eisak, originating in the

Brenner, enters the Etsch Valley at Botzen, and is joined at Brixen by the Rienz, which comes from the Puster Valley. The middle valley of the Etsch is joined on the right by the Sulzberg and Nonsberg Valley, and on the left by the valleys of the Avisio, the Fersina, and the Arsa, which originate in the Vedretta Marmolade.

6. *The Valley Systems of the Adriatic Coast Rivers.*—The Adriatic coast rivers, the Bacchiglione, Brenta, Piave, Livenza, Tagliamento, and Isonzo, rise in the Lessinian, Cadoric, Carnic, and Julian Alps; they have, generally, a simple valley system composed mainly of transverse valleys, and do not, like the Ligurian coast rivers, fall immediately into the sea, but flow through the broad Venetian plain, and empty themselves into the great belt of lagunes which are ranged round the north-west of the Adriatic. The Brenta emerges from the Caldonazzo Lake, flows eastward, through the Val Sugana and reaches the plain at Bassano. The Piave rises on the Paralba in the southern Carnic Alps, its valley trending for the most part south-west, till it opens into the plain at Valdobbiadene; its most important collateral valleys on the right are the Ampezzo Valley and the Val d'Agordo. The upper valley of the Tagliamento is a longitudinal valley extending east and west, forming a continuation of the lower Fella Valley with the Canal of Raccolana; the lower valley of the Tagliamento extends south-south-west. The Isonzo, which rises in the Triglav, flows through a valley having a general southerly direction, but composed of continual zigzags; its left bank leaves the Alpine district at the mouth of its confluent the Idria, and its right bank, at Görz.

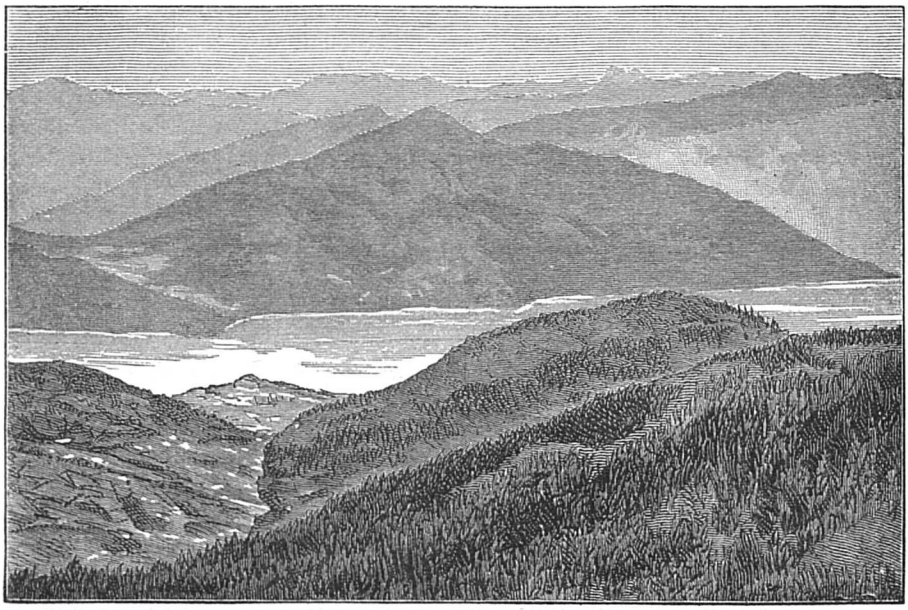
7. *The Valley systems of the Danube district.*—The Danube does not actually lie within the Alpine district, but as all the rivers of the Eastern Alps flow into it, except those of the Adriatic coast, it should be considered among the Alpine rivers. Thus, the longitudinal valleys of the Inn, the Enns, and the Salzach in the northern part of the Eastern Alps, those of the Mur and the Drave in the middle, and that of the Save in the south, with their collateral and tributary valleys, form a great Alpine system; they, however, soon broaden out and lose the peculiar characteristics of Alpine valleys, especially towards the east.

(*a*) The smaller valley systems of the Iller, the Lech with the Wertach, and the Isar with the Amper and Loisach, which belong to the Algau, the Bavarian, and North Tyrolean Alps, are only transverse valleys in the northern Lower Alps, and have neither length nor ramification of any importance. The Valley of the Lech penetrates further into the mountains than the others; it extends north-east from the Rothen Wand to Füssen, where it opens into the Suabian-Bavarian plateau; it has but few branches.

(*b*) The Inn, which rises in several mountain lakes in the Grisons, breaks through the belt of primitive mountains, in a north-easterly direction; its upper course, which reaches to the Pass of Finstermünz, forms the Engadine; below Finstermünz the course of the river turns to the north-west, but again takes a north-easterly direction which it maintains almost until it emerges from the Alps, only flowing northwards in the portion between Kufstein and Neubeurn. The collateral valleys of the Engadine, especially on the north-western side, are short and simple, but on the southern side of the Middle Inn are deep transverse valleys which belong to the Ötzthaler and Stubaier Ferners, and to the Zillerthal

and Kitzbühler Alps; such are the Kaunser Valley, the Pitz Valley, the Ötz Valley, the Lower Wipp Valley with the Stubai Valley, the Ziller Valley, and the Brixen Valley. On the left side there is only the Stanzer Valley, with its branch, the Paznaun Valley.

(*c*) The Inn receives its great affluent the Salzach, outside the Alpine district on the Bavarian plateau; it forms of itself a great valley system. It rises on the Salzach Hochlahn, north of the Gerlos Pass, but the Krimmler Ache must be considered as its head stream. Coming from the northern side of the Dreiherrenspitze, it flows northward till it has passed Wald, then eastward, receiving in this part of its course the waters from the Hohen Tauern chain which come from long transverse valleys, such as the Velber, Kapruner, Fuscher,



The Zeller Lake.

Rauriser, Gasteiner, and Gross Arl Valleys; the stream flowing from the Zeller Lake is worthy of notice. Above St. Johann the Salzach Valley turns northward, breaks through the mountains (the Salzburg Alps and the Tennengebirge), forms the Pass Lueg and the Salzachöfen, and leaves the Lower Alps below Salzburg. The Saalach, which rises on the Trist Saddle in the Kitzbühler Alps, forms a valley which is mainly parallel to the Salzach Valley, and stretches east, north, and north-east, and falls into the Salzach below Salzburg.

(*d*) The Traun, coming from the Kammer, Toplitz, Grundel, Alt-Aussee and Öden Lakes, flows south-west, and fills the basin of the Hallstätter Lake at the northern foot of the Dachstein, it runs northward as far as Ischl, where it receives the Ischl, flowing from the St. Wolfgang Lake, then north-east, broadens

out into the Traun Lake, and leaves the Lower Alps below Gmunden, receiving at Lambach, the waters of the Fuschel, Mond, and Atter Lakes, through the medium of the Ager; its mouth lies outside the Alpine district.

(*e*) The Valley system of the Enns shows a striking similarity to the Valley of the Salzach. The main valley first extends northward from the north-western flank of the Radstädter Tauern, turning eastward above Radstadt, breaks through the Northern Lower Alps between the Groups of the Grossen Pyrgas and the Buchstein on the one side, and the North Styrian Alps on the other, extends northward as far as Weyer, then north-westward and finally northward again. The most important collateral valleys are that of the Styrian Salza on the right, and that of the Steier on the left.

(*f*) The Ips, the Erlaf, the Bielach, the Traisen, the Schwechat, and the Fischa, the small Alpine affluents of the Danube in Lower Austria, form only small valley systems in the northern outliers, which stretch to the north or north-east. The whole of the upper Valley of the Ips, however, has an east and west direction.

(*g*) The Leitha, which is formed by the junction of the Schwarza, coming from the Unterberg, and the Pitten coming from the Hochwechsel, has a valley system of many ramifications, in the Lower Austrian Alps and the Wechsel.

(*h*) The valley system of the Raab, which rises on the Osser in the Fischbacher Alps, comprises besides the Raab Valley itself, the collateral valleys of the Rabnitz, the Güns, the Pinka, the Lafnitz, and the Feistritz, which, stretching to the south-east, are all enclosed by outlying mountains and ranges of hills, and only unite with the Valley of the Raab in the plain of Upper Hungary.

(*i*) The Valley of the Mur begins on the Marchkarkogel in the Radstädter Tauern, extends longitudinally in an easterly direction as far as Judenburg, from there north-east to Bruck, then, transversely, south to the neighbourhood of Leibnitz, and finally south-east to the mouth of the Mur. The most noteworthy of the collateral valleys are those of the Liesing and the Mürz on the left, and the Kainach on the right.

(*j*) The Valley of the Drave is the longest of the eastern Alpine valleys, measuring 208 miles up to Warasdin. It is a fine longitudinal valley which intersects the Eastern Alps almost from their beginning to the last outlying spurs, extending in an easterly direction. The source of the Drave lies in the Tyrolean Puster Valley, and is separated from the Rienz by the watershed of the Toblacher Feld. The Drave Valley is very narrow as far as Lienz; at this place the Isel Valley opens out, the Defferegg Valley being connected with it, both leading from the Hohen Tauern south-westward to the Drave. At Lienz the main valley widens out, but contracts again repeatedly as at Ober-Drauburg, Sachsenburg, above Villach, and at Unter-Drauburg. The collateral valleys opening on to the Carinthian Boden are, on the left the Möll Valley (from the Gross-Glockner), the Lieser Valley (from the Hafnerspitze), the Gurk and Lavant Valley (in the Carinthian-Styrian Alps), and on the right the longitudinal valley of the Gail. The enclosing mountains begin to grow lower at the mouth of the Gail and to fall back, and the broad valley loses its Alpine character. Between Völkermarkt

and Murburg, however, the valley again contracts, then broadens out into the Pettauer Feld, and opens to the plain of Warasdin below the last contraction, the Friedau. The collateral Valley of the Dran unites with the Drave Valley on the Pettauer Feld.

(*k*) The valley system which extends farthest to the south-east, is that of the Save. The Wurzener Save, which comes from the Wurzener Lake on the northern side of the Mangart block, and the Wocheiner Save which rises at the southern foot of the Triglav, unite at Radmannsdorf and form two short longitudinal valleys of an Alpine character; from that point the Valley of the Save, which extends to the south-east, and repeatedly broadens into a plain, is enclosed by a series of mountains which gradually decrease in height. At the mouth of the Zeyer Valley, the main valley contracts, and also below the mouth of the Laibach, where the river curves through the mountains in an easterly course, till it turns to the south-east above the mouth of the San on the left. The valley again becomes wider at Gurkfeld, and at Agram the Save enters the Croatian-Slavonian plain, which it intersects with many turns, at a considerable distance, in the north, from the last spurs of the Alps, and in the south, from the outliers of the Karst range.

The origin of valleys is one of the most interesting subjects of geological research, the formation of valleys being one of the most important factors in those circumstances which tend to level the surface of the earth, to equalize its heights and depths, and to create an equal balance of mechanical and chemical conditions. All valleys owe their origin either to movements of the earth's crust, or to the action of water; they may, therefore, be divided into tectonic valleys and valleys of erosion. Among the former may be included all those valley furrows whose features lead to the conclusion that they have originated in a disturbance of the strata; the latter have been worn out by flowing water. It should, however, be observed that the tectonic valleys also are constantly being transformed by erosion.

The tectonic valleys may be referred to the dislocation of the beds of rock—that is to say, owe their formation originally to the folding and tilting of the strata—but are lengthened, deepened, and widened by erosion. The valleys, indeed, may be divided into two principal kinds, according as they have their origin in folding or tilting, that is, into the longitudinal or fold valleys, and the transverse or tilt valleys. The longitudinal

valleys, that is, such as have a course more or less parallel with the strike or folding of the strata, again present various types. Vertical or crest valleys are longitudinal clefts having originated in the splitting of the dome-shaped curve of the crest, and are therefore enclosed by anticlinally disposed strata; they are called also anticlinal valleys, and valleys of upheaval. The Defferregen Valley offers an example of this kind. Trough valleys lie in the hollows of the folds, and therefore between sinclinal beds, such as the Pfitscher Valley in the Zillerthal Alps; these are called sinclinal valleys. Those longitudinal depressions which occur in isoclinal beds of a simple stratification may be called valleys of separation, or isoclinal valleys. Another kind of longitudinal valley is the result of the pushing forward and outward of the strata within the mountain folds, examples of which are numerous in North Tyrol and Vorarlberg. Another class is formed of those fold-valleys which occur on the boundary between old *massifs* and mountain chains, and proceed chiefly from the check which later foldings experienced when meeting with the solid obstruction presented by the older mass. A whole series of such valleys extends along the outer edge of the Alps. The Rhone Valley may be mentioned as belonging to it, between the Western Alps and the slope of the French central plateau, and the Danube Valley, between the northern border of the Eastern Alps and the Bohemian-Moravian *massif*.

Longitudinal valleys which pass over the fan-shaped folds have a sinclinal inclination of the strata, although, geologically, they lie in an anticlinal line (the Göschenen Valley in Switzerland is an illustration of this); those that lie in the troughs of the fan-shaped folds (as the Ursern Valley) have an anticlinal disposition of the strata, although geologically they are sinclinal.

The tectonic valleys, or transverse valleys, intersect the strata at, approximately, a right angle, and may be subdivided into three different kinds, diaclinal valleys when they break through a

series of folds, kataclinal when they run in the direction of the inclination of the strata, and anaclinal when they run in an opposite direction. One and the same valley can belong, at different points, to any of these three kinds. Transverse valleys may be originally caused by ruptures of the crest, afterwards widened and deepened by erosion, but are, in most cases, purely valleys of erosion, whose origin is to be found in periods preceding the formation of the mountains, and in whose further development the force of erosion keeps pace with that of dislocation resulting from upheaval.

The action of erosion is exhibited most clearly in the valleys where the rocks are bedded horizontally, or nearly so, or in massive rocks, such valleys being called valleys of erosion or water-worn valleys. It is not, however, flowing water alone, but also ice, frost, rain, and wind which perform the work of denudation and chiselling, and carve out the exterior form of the earth's crust.

The importance of erosion in the formation of tectonic valleys has often been shown.

In consequence of the geotectonic conditions of such valleys, the action of erosion is at times impeded or accelerated, as rocks of different mechanical or chemical resistance are exposed. Every separate section of a valley, therefore, will in the course of time pass from one stage of valley formation to another. The phases of the work consist of a constant repetition of cutting out, widening, filling up by the deposition of transported material, the removal of this material, then more cutting out till the course of the valley has received the curve of descent corresponding to the composition of its floor. The most striking indication of these periods of valley formation are the terraces of heaped-up matter, often of great thickness, which are found in some river valleys. In the Valley of the Inn, for instance, such a terrace of *débris* is found, 800 to 1300 feet thick, and forms the so-called "Mittelgebirge" along the Inn. These heaped-up

terraces must not be confounded with the flank terraces, which are remains of former valley-bottoms lying at a higher level, and are often found on both sides of the valley.

These different kinds of terraces are common to all river districts. The flank terraces correspond as regards their level, to other stages of the valley farther back among the mountains, and appear to be the remains of a former connected valley system, while lower down, new and deeper systems have been worn out and are gradually working backwards into the mountains and reducing the former valley-bottoms to a dwindling remnant.

The old valley-bottoms correspond to the different levels at which the river has flowed, the highest being the oldest, and the deepest the most recent, and are a proof that the course of the water had adapted itself to the changes in height of the valley floor. Penck, in his "Zeiten der Thalzuschüttung," has shown in an interesting manner, that the heaping-up of the masses of loose material marks a period of rest in the construction of the valleys, caused by climatic conditions. The filling of the valleys occurred in the glacial age. The harsh climate of that period loosened the earth, and the small streams were so laden with loose stones, that the large rivers had not the power to master the supply of rubbish. The loose stones brought down from time to time lay in the bed of the river, the valleys became filled with them, and during a period of especially active denudation, the formation of the valley came to a standstill, and was only continued again when a warmer climate prevailed. The German Lower Alps have been three times ice-bound, the ice-streams of the Alps have three times pressed forward, and three times receded; consequently, the rivers of the German Lower Alps have along their banks, three different heaped-up terraces, and the same number may be traced, though showing less regularity, in other valleys.

At the period when the valleys were being filled up, the

course through them was often obstructed, and old passages and river-courses were reconstructed out of the remains of the old valley-bottoms, frequently corresponding in no way to the present course of the rivers, and showing that there are valleys, belonging to an earlier period in the history of the mountains, which have been abandoned by their rivers; it is evident that the present river-beds, which are often of very varied construction, are composed of old, of more recent, and of quite recent formations, and have been constructed at the cost of the older river systems. The Valley of the Salzach, between Taxenbach and Schwarzach in the Austrian Alps, belongs to the most recent stretch of the valley. Before the former watershed was broken through by a landslip in 1875, in its last portion above Lend, in the neighbourhood of the famous Unterstein Tunnel, the waters of the Pinzgau as far as the Rauriser Ache flowed through the transverse valley at Zell am See in the district of the Saalach. The magnificent landslip in the narrow part of the valley at Unterstein which took place in the last century, the *débris* of which dammed up the river for a distance of a mile, is a striking example of the continued action of valley formation. The "Gesäuse," between Admont and Hieflau, is also a comparatively recent breach of the Enns, which formerly made use of the Buchauer Saddle and the Valley of St. Gallen, reaching its present transverse valley in a north-westerly direction at Altenmarkt. Pursuing this course of valley formation still farther back, the huge deposits of *débris* on either side of the present course of the Salzach between Taxenbach and St. Johann, as well as on the present watershed between the Salzach and the Enns at Wagrein, show that before the transverse Valley of Zell am See, the Pass Leug, and the Valley of St. Gallen were formed, or the lakes of the Pinzgau and Pongau existed, a huge river flowed from the Tauern, at a higher level than the present, in a longitudinal valley which must, from the structure of the Eastern Alps, have been magnificent, out of the

Pinzgau through the Pongau and the district of Wagrein, into the Upper Valley of the Enns, and entered the district of the Mur through the broad longitudinal furrow of the Rottenmanner, and over the low saddle of Wald. The Isère offers another example, having at one period flowed directly westward to the Rhine, below Grenoble; the broad plain of Valloire now indicates its former course.

## CHAPTER X.

### THE ALPINE RIVERS.

THE study of the Alpine Valleys has already made us acquainted with the Alpine rivers; but there still remain many facts connected with them to be noticed.

The sources of the Alpine rivers lie at very varied heights, sometimes at the foot of a mountain, sometimes on the flank, and sometimes even near the very summit. Most of them come in the form of running water, immediately from the bosom of the earth, others have their origin in glaciers and ice-fields. The latter dry up in the winter and are at their fullest in the hottest part of the summer. One kind of source is the so-called "May-springs," which burst out more or less plentifully on the slopes of mountains, on the summits of which the snow melts in the spring, principally in the month of May, and which flow as long as the supply of snow lasts. Springs which increase and diminish, or fail altogether, at regular or irregular periods are called intermittent springs. One of the most famous springs of this kind is that described by Pliny, at the Villa Pliniana on the Lake of Como, which ebbed and flowed three times a day. The most important in Switzerland is the Fontana Chistaina in the Val d'Assa in the Lower Engadine. The water springs from the rock into a spacious basin, the off-flow from which forms a strong torrent. The water gushes forth periodically, three times a day, at nine o'clock in the morning, at noon, and towards evening, there being a pause of about three hours between, during which the basin is perfectly empty. The Engstlibrunnen, in the Canton Berne, has a double periodicity, an annual one from

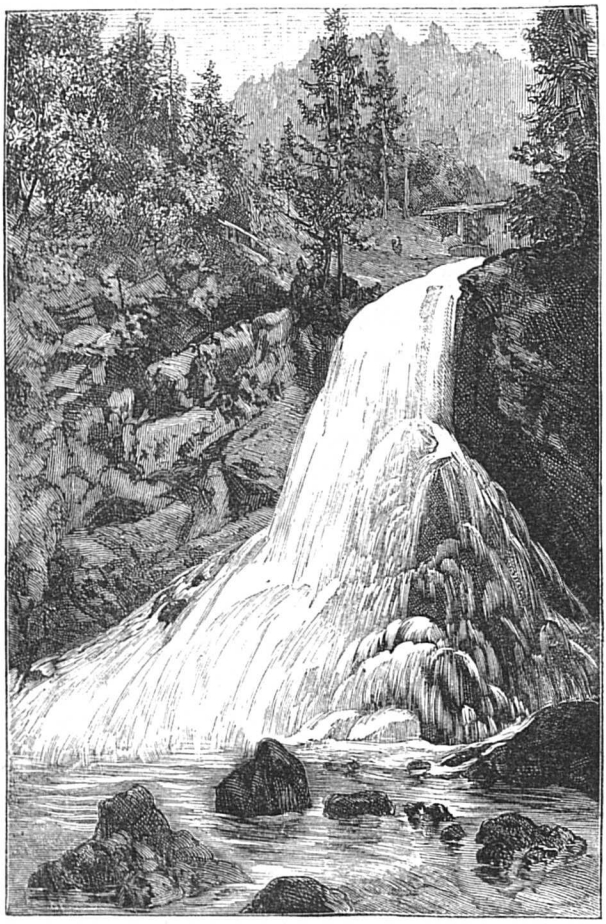
the middle of May to the middle of August, and a daily one from four o'clock in the afternoon to eight o'clock in the morning; this, however, is not quite regular. The mineral spring at Pfäfers appears annually in May, and dries up in the middle of September. This periodical flow has been especially observed in the springs of Switzerland and the south of France. All these springs flow continuously during wet weather. In explanation of this phenomenon it has been assumed that there exist underground channels of siphon form.

There are some springs which do not appear at all on the surface of the earth, but rise at the bottom of the sea and empty themselves immediately into it. The shore of the Mediterranean Sea, in that part where the Western Alps approach closely to it, is distinguished by such springs.

At Ciotat, St. Nazaire, Cannes, and San Remo, fresh water streams rise in the midst of the salt water, and attempts have been made to determine approximately the quantity of the outflow. The French geologist Villeneuve Flayosc estimates the volume of water discharged from the submarine springs of the Mediterranean Sea between Nice and Genoa to be 671 cubic feet per second. Many of the submarine springs on the Provençal and Ligurian coast rise at great depths. The spring at Cannes rises 530 feet below the surface of the sea, that at San Remo at a depth of 957 feet, and about $3\frac{1}{2}$ miles south of Cape St. Martin, between Monaco and Mentone, a stream of fresh water rises at a depth of nearly 2300 feet below the surface of the sea. All these springs are of Alpine origin.

The supply of water is very varied, some springs being so weak that they flow only in drops, or can be emptied by the hand, while others gush forth at the very outset, in the form of a strong stream, or small river. Examples of the latter kind are numerous in the limestone Alps, which are enabled by their deep clefts and extensive caverns to collect considerable stores of water in subterranean channels. Thus the Schwarzbach at

Golling forms the beautiful Golling Fall, at only a few yards from the place where it emerges from the rock. The famous spring of the Sorgue at Vaucluse discharges, according to Arago's estimate, 15,678 cubic feet of water per minute in the dry season, and nearly 47,000 cubic feet in the rainy season.



The Golling Waterfall.

Springs vary greatly also with regard to temperature. A spring which rises on the flank of the Hangerer in the Ötz Valley, at a height of 6740 feet, is only 1° C. warmer than ice.

Many springs are found, especially at the foot of limestone

mountains, which are colder than the surrounding land. This circumstance may be explained by the fact, that air, as well as water, penetrates the subterranean channels and circulates through the network of clefts and gorges, causing copious evaporation. Numerous warm springs rise within the Alp district, coming generally from the rifts in crystalline rocks, at the bottom of deep ravines, in cauldrons, or in the transverse passes of large chains, where older rocks have broken through more recent ones, and where important transpositions have taken place.

Mention has already been made of the line of warm springs along the edge of the Austrian limestone Alps, from Gloggnitz to Vienna, through Fischau, Vöslau, and Baden. The warmest springs in the Alps are those of La Motte in the Department of Isère, which have a temperature of 84° Cent., of Vinadio in Piedmont 67·5°, of Acqui 54°, of Baden in the Aargau 50°, of Wildbad Gastein 49·6°, of Bormio in Lombardy 47·5, of Aix 46°, and St. Gervais 44°, in Savoy, of the Römerbad in Styria 39°, of Pfäfers in St. Gallen 38°, of Masino on the Splügen 37·5°, and of Baden at Vienna 35°. In many warm springs an elevation of the temperature has been observed to coincide with the increase of water, in consequence evidently, of the stronger subterranean stream meeting with less hindrance in coming to the surface and so losing less heat. The water of the Brieger Bad, between Brieg and Visp in the Canton Valais, has in summer and winter a mean temperature of 34°—35°, which, however, rises to 45°—50° when the moist wind of spring melts the snow of the Oberland. Most warm springs, contain a large amount of mineral matter, indeed, very few springs, either warm or cold, are entirely free from it. Still there are a few which have a remarkably small quantity. Thus the spring at Pfäfers contains only 0·29, that at Gastein 0·35, that of Bormio 0·57 constituent parts, in 1000 parts of water.

The stream from a weak source is called a runlet, several

runlets join together and form a brook or rivulet, several rivulets form a river, rivers join together and form larger rivers. When two rivers unite, the weaker stream is usually considered to be the tributary, and flows into the other, but most frequently that is considered to be the main stream, which maintains its original direction after the junction of the two rivers. The Rhone contains a larger body of water than the Saône, but it is the Saône whose direction is continued from Lyons downwards by the Rhone. The use of the words brook (*bach*) and river (*fluss*) is very indefinite in the Alps, depending a good deal upon the amount of water found in the neighbourhood. In the high ranges which are rich in water many streams are termed brooks or torrents, which exceed both in length and volume, what would in other places be termed rivers. The suffix *sana* is also a Romanche word meaning brook (as the Rosana, and Trisana). The Noce, which flows into the Etsch on the right, is also called by the people of the German Tyrol, the Nosbach. It is hardly necessary to say that there are no great rivers within the Alp district, as they represent only the lower course of the large streams, while only the upper course of the main rivers belongs to the Alpine district. The only streams whose entire course lies within the Alps are tributary rivers, and coast rivers. The great valleys of the Po, the Rhone, the Rhine, and the Danube lie outside the Alps, while these rivers receive most of the streams from the valleys within the mountains. These great depressions form the outer border of the entire range of the Alps, and its farthest outliers; only a part of them, that is, the upper course, lies in true Alpine valleys, as in the case of the Po, the Rhone, and the Rhine, or their affluents and branches, for instance all the affluents of the Danube from the mouth of the Ill at Ulm, to the mouth of the Save at Belgrade. Or they touch the Alpine district only at single points, as, for example, the Danube above Vienna.

The waters of the Alps flow into four different seas, the North

Sea, the Black Sea, the Adriatic, and the Mediterranean. The only important seas of Western Europe which they do not reach are the Atlantic Ocean and the Baltic Sea. But the Alps, together with the chains of mountains that radiate from them, determine the character of the river systems of Western Europe; they are its great river source; rivers flow from them to every quarter, and water the great centres of modern civilization. From St. Gothard in the Central Alps, three rivers descend, the Rhine, the Rhone, and the Tessin, which empty themselves respectively into the North Sea, the Mediterranean, and the Adriatic. Two others rise in the immediate neighbourhood of the St. Gothard, the Aar, the chief tributary of the Rhine, and the Inn. Thus there are five rivers which flow from the same group of mountains into four different seas. Other mountain groups of the Alps, such as Monte Viso and the Levanna, in the neighbourhood of Mont Cenis, form centres from which streams radiate, but none can be compared in importance in this respect to the central group of the St. Gothard. The Po and its affluents, the Varaita and the Pelice, rise on Monte Viso, as do also the Ubaye and the Guil, which flow into the Durance. The Levanna block supplies the Orco, the northern Stura, and the Rheme of the Po district, the Isère, and the Arc of the Rhone district. The Ötzthaler and Ortler groups form the only important river district of the Eastern Alps, the former being divided between the Etsch and Inn district, and the latter between the Po and the Etsch district. East of the Brenner line, where the chain formation prevails, such river centres are entirely absent. All large rivers rise in the zone of primitive rocks, the sources of the Save alone, belonging entirely to the limestone mountains.

It will be evident, that the great Alpine rivers are the Rhone, the Rhine, the Po, and the Etsch; the Danube may also be reckoned with them, as it owes its great volume of water to its Alpine tributaries. To these may be added the Ligurian and

Adriatic coast rivers. As these rivers flow, as already stated, to four seas, the Alps contain the watershed between these seas, and consequently form the most important part of the chief watershed of Western Europe.

If we observe the course of the watersheds in the Alps, we shall immediately find, that they by no means coincide everywhere with the line of greatest elevation, but often even descend to the bottom of the valley. In many places the watershed is of so little height relatively, that when there is a full supply of water it passes over the watershed in the direction of the neighbouring river district. This kind of temporary bifurcation is found not only in plains but also on the tops of mountains. An example may be seen in the little lake which forms the source of the Inn, on the Piz Longhino, which at the season when the snow melts, sends its water over the neighbouring Maloja Pass to the Maira. There may sometimes be deceptive watersheds in the limestone mountains, that is to say, subterranean caverns may communicate with each other, in river districts otherwise separated. Thus the Schwarzbach, which forms the well-known Gollinger waterfall, is popularly said to be discharged from the Königsee. At any rate, the surface of the lake lies considerably higher than the point where the Schwarzbach emerges from the Göll ravine ; a part of the water must flow from the lake, through the Kuchler Loch, for when, in a year of drought (1823), the surface of the Königsee did not reach the Kuchler Loch, the Schwarzbach dried up. But a true bifurcation also takes place in the Alps. The Inn and the Rhine communicate with each other on the further side of the Sertiger Pass. There lie two small lakes, at a height of 8480 feet, which are connected with each other ; the water of the smaller lake goes through the Val Sugana to the Inn, that of the larger one through the Val Tuors to the Albula and the Rhine. Sometimes the watershed runs nearly in a direct line, sometimes it has many turns ; it may be situated at a great distance from the large river-beds or close to them, in

which latter case, it lies parallel to them, as in the Lower Etsch on the left side of the Inn. The watersheds of the Alps frequently form political, and occasionally ethnological boundaries. Many of the names suggesting separation such, as Gscheid, Scheideck, &c., indicate watersheds.

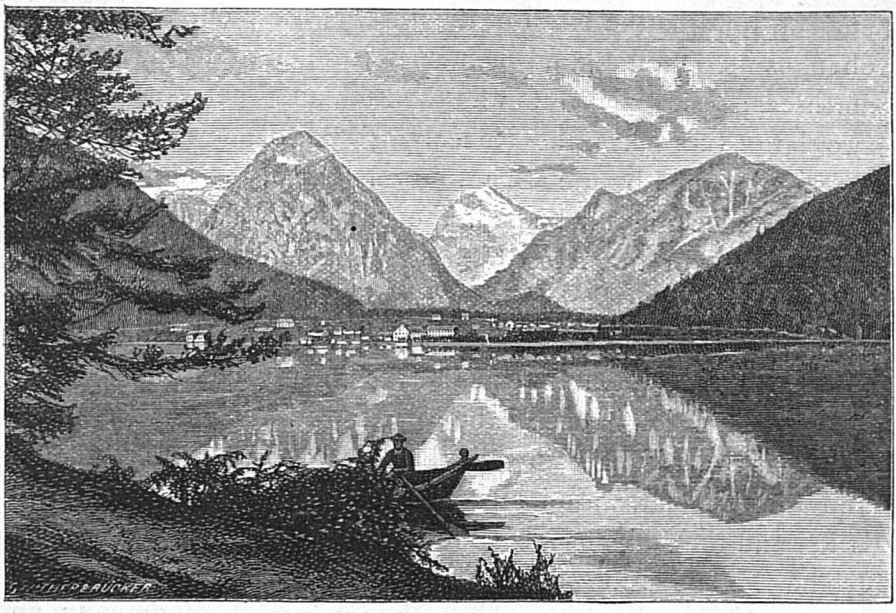
The rivers of the Alps have already incidentally been treated of, in the topographical description of the Alps, and also in the chapter relating to the valley systems. There remain, therefore, to be supplied only a few facts concerning them which have not already been mentioned.

The Rhine serves pre-eminently, to carry off the waters which come down from the northern side of the Swiss Alps. Rising immediately in the centre of them, it flows north-eastward through an important longitudinal valley, to Chur (Coire), where it turns northward, passes through Lake Constance, and forming a loop at a considerable distance from the mountains, receives the numerous streamlets which flow into it, as far as the Jura, and which for the most part unite into two rivers, the Thur and the Aar. The Rhine is usually considered to be fed by three head-streams, the Vorder-Rhine, the Medelser or Middle-Rhine, and the Hinter-Rhine, but it is actually composed of a vast number of mountain streams, which all bear the name of Rhine and are distinguished from each other by prefixes. The Vorder-Rhine, however, may be considered as the main stream; it rises at a height of 8130 feet, falling to 6825 feet from its source to Lake Constance, and again from there to Basle to 492 feet. About sixty small streams flow into the Vorder-Rhine between its source and Reichenau, where it unites with the Hinter-Rhine. Those coming from the south are even larger than those which flow down from the north, the latter being generally mere mountain torrents, rushing down from narrow ravines and short valleys, and often causing great devastation, in consequence of the rolling masses of *débris* which they bring with them. Between Reichenau and Lake Constance, the Rhine receives, on

the right the Plessur, the Landquart and the Ill, on the left the Tamina. The first affluent below Lake Constance is the Thur, which drains the district of Appenzell, the Thurgau and St. Gallen. The next is the great collateral river, the Aar, which also rises in the centre of the Alps of Switzerland. The lake through which it flows was formerly not much smaller than Lake Constance, but has, in more recent times, been divided into two lakes, those of Brienz and Thun. The Aar flows with a rapid current, towards the chain of the Jura, at the point at which it changes its direction, and then runs parallel to it towards the north-east, receiving on its way the Zihl, and the waters of the two large Jura lakes, the Neuenburg and Bieler Lakes, which are strengthened by the stream flowing out of the Murten Lake. Thus it collects in its bed all the streams which rise on the northern side of the Alps from the Diablerets to the Grauen Hörner above the Tamina Gorge. The lower affluents of the Aar, again join together, and flow into the main stream by two great arteries, the twin streams of the Reuss and the Limmat. The Reuss, which is one of the wildest of the Alpine rivers, exhibits, as regards its main valley, a resemblance to the Tessin, and the Limmat, with its two neighbouring lakes, the Walen Lake, and the Lake of Zurich recalls the features of the Aar.

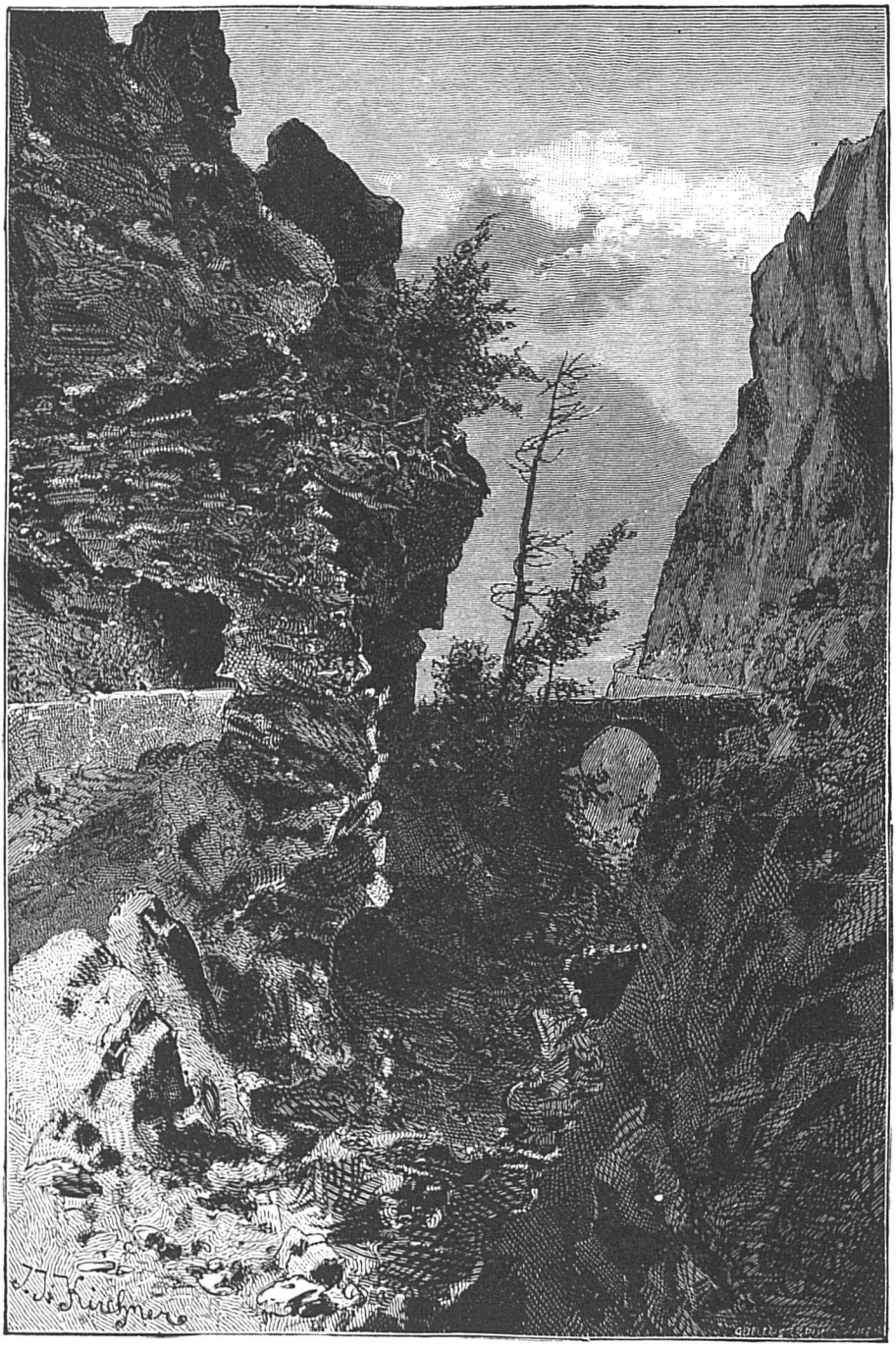
The Danube is the second in size of the large rivers which collect the waters of the Alps, though not itself actually an Alpine stream. The two largest tributaries which flow into it from the Alps are the Inn and the Drave. The Iller, which is formed by the junction of three mountain streams, the Breitach, the Stillach, and the Trettach, at Oberstdorf, is unimportant in size, and leaves the Alps at Immenstadt. The Lech has a longer course among the mountains, and breaks away from them in a wild cataract at Füssen. The Isar, which resembles the Lech in its direction, and in the formation of its valley, may be called a lake river, since it receives the waters of the numerous lakes of the Bavarian Plateau and the limestone Alps, through

the medium of its affluents, the Loisach and the Ammer. These lakes, the Eibsee, the Walchensee, the Kochelsee, the Staffelsee, the Ammersee, and the Würmsee, all lie on the left side. Only the stream from the Achensee discharges itself on the right bank. The Inn is one of the most important of the Alpine rivers; like the Rhine, it rises in the central zone, and breaks its way through the limestone zone. This river system is striking



The Lake of Achen.

from the fact of it lying almost entirely on one side of the main stream; for, while it receives on the right the copious streams of the Kaunser, Pitz, and Ötz Valleys, the Sill and the Ziller, and, outside the Alps, the Alz combined with the stream from the Chiemsee, and the Salzach after being joined by the Saalach, on the left bank the only stream of any importance is the Sana, which is formed by the junction of the Rosana and the Trisana. The lake-forming river of the Salzkammergut is the Traun, which flows into the Danube below Linz. The last of the large



The "Via Mala," in the Valley of the Hinter Rhine.

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rivers on the northern slope of the Alps is the Enns. The similarity of its valley to that of the Salzach has already been remarked ; like the latter also, it rises in the Tauern Chain, and breaks its way through the northern limestone Alps. As the Inn collects part of the waters which flow northward from the Alps to the Danube, so does the Drave unite a great part of those which flow to the east. With regard to its valley, however, it differs from every other river in the Alps, as it remains longitudinal throughout its course. It flows into the Danube at a considerable distance from the Alps. Its river system, like that of the Inn, is much more fully developed on one side than on the other, for on the right side it receives only the Gail and the Dran, which flow nearly parallel to one another, while on the left it receives the large streams flowing from the Tauern (the Isal, the Möll, and the Lieser), then the Gurk and the Lavant, and finally the Mur. The latter brings with it most of the water from the Lower Tauern, the Carinthian and Styrian Alps, and the Hochschwab Group, and turns in a longitudinal valley to Bruck, whence it winds, near the border of the Alps, towards the south-east. The Drave is hardly inferior to the Save as regards size. It begins its course in two streams, which enclose the Triglav from the north-west to the south, near the south-eastern end of the Alps, and at Krainburg enters a wide valley lying 722 feet above the sea ; it consequently receives but few affluents from the Alps.

The Rhone follows the north-western and western course of the Alps, as the Danube follows the north-eastern and eastern border. The Valley of the Rhone trends south-west, while the Valley of the Danube trends south-east. The courses of the two streams present many analogies, which would appear more strikingly if the Rhone and the Saône respectively had been named on the same principle as the Danube and the Inn, namely, if the main stream had retained the name Saône. That is to say, the Valley of the Rhone bears precisely the same relation to the

Saône as the Valley of the Inn does to the Danube. The Rhone turns suddenly at Lyons, and follows the normal direction of the Saône, as the Inn does that of the Danube. The Rhone is the Alpine river of the high country of the Valais, while the Inn is the Alpine river of the high country of the Engadine and Tyrol. The course of both lies in the largest longitudinal valleys of the Alps, in the same direction from south-west to north-east, and both break through the outlying parallel lime-stone chains in the north of the Alpine range. There are also remarkable analogies between the Rhine and the Rhone. These two great rivers of almost equal volume, at first flow in entirely opposite directions, then suddenly turn boldly to the north, each flowing through a lake of considerable extent, the one through the Lake of Geneva, the other through Lake Constance, break through the parallel chains of the Jura in rapids and cataracts, and finally leave the mountains and flow straight away, the one to the North Sea, the other southward to the Mediterranean. The lower course of the Rhone lies entirely outside the Alps, as does also the lower course of the Danube, but in the neighbourhood of Avignon and Carpentras, it washes the western foot of Mont Ventoux and the Montagnes de Lux in the extreme south-western outliers of the Alps.

The Po differs from the main streams of the Alps in that it lies entirely outside the range, with the exception of what may be called its roots, but its whole course follows the southern flank of the Alps, and at its upper end it is surrounded by them almost in a bow. Its course winds very little, and its affluents are all shorter than those of the other Alpine rivers. Though at an equal distance from the mountains, it lies much lower than the channels of the Rhine, the Rhone, and the Danube. After a course of only twenty-three miles it has descended at Carde, between Turin and Saluzzo, to a height of only 1035 feet, the same height at which the Rhine lies at its junction with the Aar, after a course of eight times the length. Being shut in between

the Alps and the Apennines, its district is confined to a single valley, which from beginning to end varies very little in breadth, and presents very simple boundary-lines. The Po has a steep descent into the plain, and takes for a short distance its future main direction to the east; then it turns to the north, and does not recover its eastward direction till it has passed Turin, this it afterwards maintains till it falls into the Adriatic Sea. Its affluents are, for the most part, Alpine, but in its middle and lower course (which, however, can hardly be defined in this river of the plain) it also receives collateral streams from the Apennines.

The waters of the Ligurian and Maritime Alps are collected by the Tanaro, the principal branches of which are the Bormida and the Stura. Among the other Alpine tributaries of the Po, the most important are the Dora Riparia, and the Dora Baltea, especially the latter, which receives all the smaller streams of the Pennine Alps that flow towards the south between Mont Blanc and Monte Rosa. All the collateral streams of the Upper Po bring down with them great masses of *débris* and silt, which they deposit in the sluggish river. In the course of centuries they have so raised the bed of the stream that it has been necessary to enclose the river between dams ten to twelve feet high, in order to protect the low-lying lands from inundation. The tributaries of the Lower Po, the Ticino, the Adda, the Oglio and the Mincio, flow with clear water into the main stream, having deposited the silt they brought down, in the lakes which they form on their way.

The district of the Etsch (Adige), belonging like that of the Po to the southern side of the Alps, differs remarkably from the other large river districts, in the great breadth of its upper portion, and the narrowness of its lower portion where affluents are entirely absent. In the latter part the Etsch appears to be completely shut in between the district of the Po and that of the Bacchiglione and Brenta. The river system of the Etsch has consequently a tree-like form, the upper branches of which are

formed by the Eisak and Rienz, the Avisio and the Noce, as well as by the Etsch itself. The Etsch and the Eisak rise in the central zone of the Alps and the Etsch breaks through the limestone zone, without receiving, in its long course, any important addition to its waters.

Besides the Po and the Etsch, a large number of smaller rivers flow to the Adriatic Sea. These Adriatic coast rivers all rise in the eastern portion of the southern zone, from the Lessinian to the Julian Alps. Their course is steep and destructive, and the outlying plain is therefore formed of *débris;* by the deposition of rubbish they have helped to form lakes, which, however, are generally soon filled up again. The Bacchiglione, the Brenta, the Sile, the Piave, the Livenza, the Tagliamento, and the Isonzo belong to this class of wild torrents.

The Ligurian coast rivers are also lovely mountain streams; they rise only in the southern outlying Alps, and not in the high peaks in the middle, and have therefore but a poor supply of water. Like the larger streams of the Adriatic coast, they have not the regular supply of water of the inland rivers, and their volume, which is dependent on rain and snow, diminishes as quickly as it rises. The Var is the most important; it rises in the Maritime Alps, and falls into the sea between Nice and Antibes. The great fall of the Ligurian coast rivers causes serious destruction to the steep southern slope of the Maritime Alps, and consequently a piling-up of rubbish on the side towards the sea-shore.

As the Alpine rivers either have their upper course in the mountains, or are mountain streams throughout their whole length, they have generally a considerable fall, though in this respect also there is a good deal of variety. The fall of a river virtually coincides with the angle of inclination of the special stretch of valley, and in mountain valleys, the angle of the valley-floor being ascertained, the same serves for the river also. The mountain torrents have, relatively, the greatest fall, an in-

clination of 10° to 15° being not uncommon. But the greatest inclination conceivable is shown in the waterfalls, since their waters pass over a perpendicular or nearly perpendicular ledge of river-bed. As regards the landscape, the waterfalls are among the most important objects in the Alps. When accompanied by sparkling snow and fields of ice, and glistening lakes, they form one of the chief beauties of the high mountains. With regard to their position in the valleys, they may be divided into two kinds, the first of which are situated at the mouth of a river, where its waters are discharged, and the other in the valley itself; the Lower Gastein Fall is a good example of the former kind, and the Upper Gastein Fall of the latter kind. Every fall at the mouth of a river moves farther back into the valley, and becomes a valley fall. The early stages of this process may be well observed in the Lower Gastein Fall. It does not follow, however, that every valley fall has once been at the mouth of a river; it may sometimes be the result of dislocation or of filling up: flowing water having always the tendency to moderate the slope, and to restore the level of the valley bottom, it cuts into the ground on the one hand, and wears away the edge on the other, so that the angle of inclination of the floor becomes constantly smaller. The water which at first fell over the perpendicular rock in a single stream afterwards descends in a step-like series of falls, or cascades, and as the same process is repeated in each of these falls, it gradually becomes a cataract; at length the descent becomes so modified that the water no longer falls, but passes over the rocks with great speed, and the former waterfall reaches its last stage of development, the rapids. Examples of these different stages may be seen in the Schwammbach Fall in the Tyrolese Pitz Valley, which descends in a single bow of water, the Gsöllbach Fall, which is composed of nine cascades one above another, and the Salzachöfen, which are rapids, and are the last stage of a former fall of the Salzach in the narrow valley. When a fairly broad band of water runs

quietly over a steep descent of rocks, it forms what is called in the Alps a "Schleier" (Veil) fall, and when the falling stream is not strong enough to reach the bottom of the descent in a compact body, but becomes scattered in the air, it is called a "Staub" (spray) fall.

The number of waterfalls in the Alps amounts to many thousands; two hundred and fifty large falls are known in the Bavarian and Austrian Alps alone. It will be evident that waterfalls are most numerous in the upper reaches of rivers, and more frequently met with in transverse than in longitudinal valleys. Waterfalls which come from the glacier regions of the high mountains of primitive rock have a poor supply of water in wet weather, because the region of ice which feeds them then becomes colder and the surface does not melt; those which come from the limestone mountains are at their best after wet weather. The latter dry up after continuous hot dry weather, while the former are then in their fullest beauty, because then the glacier-streams flow most copiously.

The Krimmler Falls, in the Pinzgau, are the highest in the Alps, the four cascades being altogether 2085 feet high. The Pissette, in the Sixt Valley at Chamounix, takes the second place, its height being estimated at 1900 feet. The height of the Wenger Fall, in the Pinzgau, is given as 1869 feet, but not with certainty. The Gsöllbach Fall or Verpail Fall, in the Kaunser Valley in Tyrol, takes the fourth place, falling in nine cascades from a height of 1370 feet.

The following is a list of the most important waterfalls of the Alps:—

The Guil Fall, in the upper Valley of the Guil, an affluent of the Durance, on the north-western side of Monviso.

The Cataract of the Orco above Locana.

The Gua Fall, a fine precipitous fall of the Gua torrent, 230 feet high, in the Malaval ravine in the Romanche district.

The Pisse Fall, which falls in spray 656 feet into the Romanche, below the Col du Lauteret.

The Fall of the Moulin torrent by the village of La Garde in the Romanche Valley.

The Cascades of the Sorgue at Vaucluse.

The Fall of the Glaise at Moutiers, in the Isère Valley, which descends from the Crêt du Ré.

The Fall of La Chapelle, in the Arc Valley.

The Fall of the Arve, at Servoz.

The Nans d'Arpenaz, a fall of spray 852 feet high at Balme, in the Arve Valley, between Cluses and Sallanche.

The Pissette, in the back part of the Sixt Valley (near the Chamounix Valley), said to be 1900 feet high.

The Poyaz Fall, in the Berard Valley, a collateral of the Trient Valley, on the Aiguilles Rouges.

The Lower Cascade of Barberine in the Val Orsina.

The Cascades of the Tessin in the Val di Tremola.

The Pisse Vache or "Brautschleier" (Bridal Veil), a fall of the Salenfe, 127 feet high, near St. Maurice in the Rhone Valley.

The Tosa Falls in the Formazza Valley, the finest, the Cascata di Fruth, descending in three leaps, 656 feet.

The Devera Fall, at Baceno in the Val d'Antigorio (Tosa Valley).

The beautiful Buffalora Fall in the Misox Valley.

The Moësa Falls, also in the Misox Valley.

The splendid Madesimo Fall, thundering down 850 feet, in the Val San Giacomo.

The celebrated Staubbach Fall, in the Lauterbrunnen Valley, 1000 feet high.

The Rosenfall and the Spiesbachfall, in the Lauterbrunnen Valley.

The Trümmelbach Fall coming from the Jungfrau out of the Trummel Valley to the Lauterbrunnen Valley.

The six Schmadribach Falls, in the Ammerten Valley, descending from the Breithorn.

The Sefinen Fall, in the Sefinen Valley, a collateral Valley of the Lauterbrunnenthal.

The Giessbach Fall, which descends over fourteen ledges into the Lake of Brienz.

The seven Reichenbach Falls, in the Hasli Valley, of which the sixth, 245 feet high, is the finest.

The Handeck Fall of the Aar, in the upper Hasli Valley.

The Falls of the Reuss.

The Schwarzbach Fall, the Spritzbach Fall, the Milchbach Fall, the Stäubi Fall (coming from the Brunnthal), and the Lammenbach Fall, all five in the Maderaner Valley.

The Waterfalls of the Hinter-Rhine.

The beautiful Weissenbach Fall in the Valley of the Hinter-Rhine.

The Tamina Falls, in the Tamina Gorge.

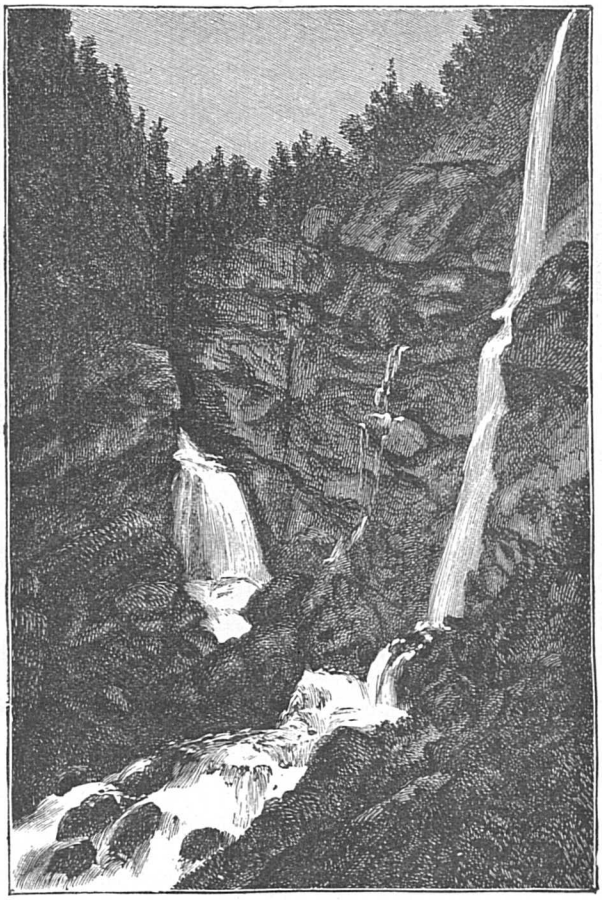
The Fluhbach Fall, 260 feet high, at Mellau, and the Kobelbach or Mellauer Fall, 311 feet high, in the district of the Bregenzer Ache.

The Pisoc del Fallun, which falls from the Val d'Assa into the Lower Engadine.

The Waterfall of the Stallanzer Alpe, 470 feet high, in the Christina Valley, west of the Kaunser Valley.

The Gsöllbach or Verpail Fall in the Kaunser Valley, consisting of nine cascades, 1370 feet high.

The Stuiben Fall and the Schwammbach Fall, in the Pitz Valley.



The Waldbach Fall.

The Ötz Falls at the opening of the Ötz Valley into the Valley of the Inn.

The Great Stuiben Fall of the Hörlochbach.

The Brunigbach Fall above Feuchten, in the Ötz Valley, 425 feet high.

The Melach Falls, in the Melach Valley of the Stubai Group.

The Sintersbach Fall, 212 feet high, at Pass Thurn, the beautiful Schleier Fall in the Zephyrau near Kitzbuhel, and the Kirchdorf waterfall, 330 feet high, all three in the district of the Kitzbühler Ache.

The Stäuhi of the Oy Valley near the sources of the Iller.

The Stuiben Fall of the Plansee Ache.

The four magnificent Krimmler Falls in the Pinzgau, together 2085 feet high.

The Kitzloch Fall at the entrance of the Rauris Valley.

The Fall of the Gastein Ache, at Lend, 230 feet high, by which the river discharges itself into the Salzach.

The two Falls at Wildbad Gastein, 196 and 296 feet high, the Bären Fall, the Kessel Fall, and the Schleier Fall, all in the Gastein.

The Wenger Fall, said to be 1870 feet high, by which the Wenger torrent discharges itself on the left, into the Salzach, at Schwarzach.

The double Gollinger Fall, 202 feet high, at Golling, on the Salzach.

The Kesselbach Fall, on the Königsee.

The Waldbach Strub, 330 feet high, the finest fall of the Salzkammergut, by which the Waldbach discharges itself into the Hallstätter Lake at Hallstadt.

The Traun Fall at Roitham, only about forty-five feet high, but important on account of its great volume of water.

The Tauern Fall, a fall of spray 660 feet high, which is formed by the Tauern Ache near the sources of the Enns, on the northern side of the Radstädter Tauern.

The Lassing Fall, which descends 412 feet, to the Erlaf in three cascades.

The Falls of the Möll, the Zlapp Fall (262 feet high), the Zirknitz Fall (196 feet), the Jungfern Sprung (426 feet), the Gössnitz Fall, the Kessel Fall, and the Leiterbach Fall (212 feet), all in the Möll Valley or its tributaries.

The Fallbach Fall, 328 feet high, the Göss Fall, the Schleier Fall, the Melnik Fall, the Hochalm Fall, the Zwillings Fall, 245 feet high, in the Maltein Valley.

The Rinka Fall, 393 feet high, which is formed by the San, in the back of the Logar Valley.

The Rothwein Fall, a splendid series of cascades of the Rothwein torrent at Veldes in Carniola.

The magnificent Pischa Fall in the Münster Valley.

The Rummbach Fall at Taufers in the Taufer Valley.

The Etsch Falls above Meran.

The beautiful waterfall of Sardagna, west of Trient on the right bank of the Etsch (Adige).

The Ponale Fall, which is formed by the Ponal (the river flowing through the Ledro Lake) where it falls into Lake Garda.

The velocity of the current of rivers depends on almost the same conditions as their fall. It is therefore greatest in mountain torrents, less in rivers, and may be very slight within the Alpine district in the more level stretches of valley. In torrents having a fall of 6 in 100, the velocity is said to be 45 feet a second. The velocity of a river often gives the measure of its navigability. In

order that a river be available for rowing boats up the stream, its rapidity should not exceed four feet a second. Consequently the number of Alpine rivers, so available, is very small, but a far greater number may be used in the valleys, or for floating timber down them.

The velocity of a river at a given point varies with the amount of water. At high-water the volume of the stream is double, ten times, or even thirty times as great as when it is low, and the velocity of the current is also increased five or ten-fold. The power of transport also is dependent on the volume and rapidity of the stream. The loosened, broken, or crumbled portions of rock, with which the river is laden, will be carried along in quantity proportionate to the transporting power of the water. The heaviest stones will naturally lie at the bottom of the stream, where, on account of the pressure of the upper layers of water and the friction, the power of transport is smallest.

The following numbers, which may be taken as a standard for the transporting power of running water, are taken from De Lapparent's "Traité de Géologie:"—

| Rapidity of stream. | Material transported. |
|---|---|
| $5\frac{1}{2}$ inches per second | Coarse silt. |
| $7\frac{1}{4}$ " " | Fine sand. |
| 11 " " | Coarse river sand. |
| 2 feet " | Fine gravel. |
| $3\frac{1}{2}$ " " | Coarse gravel. |
| $4\frac{1}{2}$ " " | Smooth stones. |

In all the larger Alpine Valleys of a certain breadth, possessing a flat bottom, and having a comparatively moderate slope, it may be observed that the rivers oscillate from one side of the valley to the other. Thus, the Rhone at Visp and at Turtman flows on the right side of the valley, at Gampinen on the left, near Sieders again on the right, immediately afterwards at Chypis on the left, at Sitten on the right, at Vetroz on the left, and so forth. The same changes of position may be seen in the Rhine and other

rivers. This meandering of the rivers is usually the result of the deposition of heaps of rubbish from the collateral valleys, which, on account of the manner of their formation and of their shape, are called rubbish cones or deposit cones. When the deposit from a side-valley has reached such size and consistency, that the stream in the main valley cannot flow over it, it pushes the river towards the opposite side, thus forming a curve round the cone. If the next cone lies on the same side, the river will remain on the other side, but if the cone occurs on the opposite side, then the river must turn again to the side on which it flowed before. Some of these cones attain an enormous size.

Rubbish heaps of this kind occur also at the mouths of rivers, in inland lakes, or in the sea, with the difference that, in their earlier stages at least, they remain under water. In the sea they lie in an almost horizontal position, the material of which they are constructed being fine sand and silt. Those from short coast rivers have a steeper inclination, as they bring with them stones as well as sand. In lakes the slope sometimes reaches 35°, as the composition of the heap is largely due to loose stones. The deposit at the mouth of rivers sometimes forms an ever-increasing foreland along the shore, such as that already noticed in the case of the Ligurian coast rivers. The same thing may be remarked in the Alpine lakes. Large maps show, at the mouths of rivers and torrents, tongues of land of varied size, of such a nature that the river mouth appears to be bordered on either side by low wet ground, as, for example, in Lake Constance where the Rhine, especially, has formed a broad foreland, and in the Lake of Lucerne, at the mouths of the Aa and the Muotta; the Zinkenbach has already produced a considerable contraction of the narrow lake of St. Wolfgang. The same kind of action often causes the formation of deltas in the Alpine lakes; the Rhone and the Dranse have formed true deltas at their mouths in the Lake of Geneva. It is evident

that in this way the area of the lakes is gradually being lessened, and, indeed, will eventually be entirely filled up with the silt of the rivers, and a level plain will take the place of the lake basin. Many Alpine rivers have already filled up their upper basins, and the process is now being continued in the lower basins. If the annual deposit of such streams could be closely observed, and exactly measured, and the depth of the former lake ascertained by means of boring, it would be possible to determine, approximately, the number of centuries that had been requisite to accomplish the great work of filling up. The sounding of a basin still filled with water would give the space of time required to fill it up completely. Such observations could easily be made, on the Isthmus of Interlaken, at the foot of the Bernese Oberland, so well known to tourists, and would at once determine the length of the geological period during which the streams descending from the Jungfrau have been at work. For this observation, all that would be necessary is a measurement of the present deposits of the wild Lutschine torrent, and an estimate of the cubical contents of the Isthmus of Interlaken, which the stream has thrown up as a sort of dam, separating into two lakes what was formerly but one single basin.

The last action of the rivers to be noticed is an abnormal rising of the water. The velocity of the stream increases with additional depth, as does also the power of propelling and transporting. The propelling power is said to be proportional to the sixth power of the velocity; therefore with the doubling of the velocity of a river, its propelling power will rise sixty-four-fold, and with the trebling of it, to seven hundred and twenty-ninefold. It is therefore hardly astonishing to hear that the Linth, at a time when the water was high, was able to move blocks weighing 110 lbs, that in the flooding of the Bagne Valley, in the year 1818, blocks containing several thousand cubic feet were carried from the Dranse into the Rhone Valley, or that in 1882, at Ebfaltersbach, in Tyrol, a piece of rock the size of a small

house was carried by the Drave for more than 10 miles. The causes of these floods are a long continuance of wet weather and rapid melting of the snow. The consequences of these occurrences are especially noticeable in the high mountains, in the real mountain streams, because the narrow valleys and the great fall cause a rapid confluence of the masses of water in the channels. But as these meteorological conditions occur only from time to time, the streams sometimes swell suddenly to an abnormal height, while for the greater part of the year they have a moderate or even a slight amount of water. These great fluctuations in volume are characteristic of mountain streams and torrents. Small torrents have often no water at all in dry seasons. The Var, in the Maritime Alps, may be taken as an example of the extraordinary fluctuations to which mountain streams are liable at different seasons of the year. The volume of water at the mouth of this little river varies from 988 to 141,240 cubic feet per second, that is in a ratio of 1 to 143, and this ratio would be still greater if the fluctuations were taken above the mouths of the Vaire, the Tinea, and Vesubie.

If the swollen stream has to go through a narrow passage, the water rises 70, 100, or even 130 feet. This may easily be seen in the narrow gorges on the Italian side of the Alps, the streams of which are fed by the snow-fields of Mont Blanc and Monte Rosa. The Dora, the Sesia, and many of their affluents, have to flow through gloomy ravines, in which their waters, having at the time of flood a depth ten times greater than their breadth, rush down with the velocity of an avalanche. With these floods in view, the inhabitants of the mountains often build their foot-bridges more than 160 feet above the bed of the stream. In the wide parts of the valley the swelling of the stream causes an inundation. Overflowing the banks, the water spreads far over the bottom of the valley, covering meadows and fields, often tearing down houses and trees, and even carrying away the fertile earth.

The flooding of the mountain streams, however, would not work such havoc, if they were not assisted by other agencies. The stones and *débris* which they carry away have previously been loosened by atmospheric action, and have fallen from the upper slopes of the mountains. The slopes are protected from destructive atmospheric action, however, by a covering of vegetation, but if this is wanting, the work of destruction proceeds without other hindrance, than such as may be presented by geological conditions. Probably no other portion of the earth can exhibit such rapid progress of destruction as the French Alps. These mountains are chiefly composed of very hard rocks, especially where they command the districts of the Durance and its tributaries; these rocks, however, alternate with others which are very easily attacked by the loosening action of water. Everywhere huge walls may be seen resting on a weak basis. Marl, slate, and other crumbling rocks, are gradually washed away and fall, dragging down with them the firm rocks which rest on them, which then slowly slide down into the valleys. The action of the mountain streams is the main cause of the destruction; but it is due more to the shortsightedness of the inhabitants of the district than to the geological nature of the land. The bare rocks of Dauphiné and Provence were formerly overgrown with vegetation, partly forests, which retarded the flow of the rain and melted snow on the surface by absorbing a great part of it, and held the loose rocks together. In the course of time the woods were cut down by greedy speculators and ignorant peasants, and with the woods they destroyed their possessions. The rain and melted snow, being no longer retained by the roots of the trees on the mountain flanks, rushed down into the valley, driving before itthe *débris* of the mountains. Goats and sheep nibble away what is left of the bushes and herbs; gradually the whole soil has vanished, and the bare rock has appeared; the flanks of the mountains are furrowed with deep channels and gorges, which in a rainy season are filled with wild torrents that

formerly did not exist. In many places no green leaf is to be seen for miles; only at rare intervals, a poor patch of turf is found. Man has disappeared with the forests. At the present time the southern Alpine valleys are becoming more and more desolate, and less inhabited, and the time may almost be predicted when the departments of the Upper and Lower Alps will have no native population, unless measures for reforesting, which have been found effectual in special places, are applied to the entire district of the French Alps.

## CHAPTER XI.

### THE ALPINE LAKES.

THE lakes of the Alps, which are among the most interesting objects of the range, may be divided into two classes, border-lakes, and mountain-lakes. The border-lakes, as the name implies, are found on the border of the Alps, and are of considerable size, but are situated at no great height above the sea-level, while the mountain-lakes lie among the mountains, are of no very great extent, and are met with at any height above the sea at which it is possible for water to flow.

Valley-lakes are a sort of transition form between border-lakes and mountain-lakes, and partake of the characteristics of both. Thus lakes are found in every stage of the range, from the lower boundary of the snow region down to the northern and southern outlying hills. Their distribution, however, within the Alps is very irregular. The Ligurian and Maritime Alps, the Mont Viso Group, the Alps of Provence and Dauphiné, and also the Mont Blanc Group, can show but a small number of lakes, and some of these are little more than ponds. In the east of Switzerland, also, the different chains of mountains which extend to the mouth of the Theiss are almost destitute of lakes, with the exception of Southern Bavaria and the Salzkammergut, where several basins fill up the narrow valleys, which nearly all extend north and south between parallel chains of mountains.

The large lakes, which are the chief pride of the Alps, all lie round that central group, in the midst of which the St. Gothard stands, and in the plains and valleys which under various names

are bounded by the parallel chains of the Jura. These lakes generally have elongated basins, lying sometimes south-west and north-east, and sometimes in a direction at a right angle to this, south-east and north-west. The large basins at the foot of the limestone Alps and the Jura, such as the Neuenburg, Biel, and Murten lakes, have the first position; the lakes of Brienz and Sarnen and the lakes of the Engadine have the same direction, and the large lakes on the Italian side, from the Lago Maggiore to Lake Garda, lie almost parallel with the Jura chains and lakes. The lakes of Constance, Zurich, Sempach, Zug, and Thun, on the other hand, have a situation at right angles with the above-named lakes. The two grandest lakes of Switzerland, those of Geneva and Lucerne, owe their remarkably beautiful form to a combination of these two directions, the Lake of Geneva being a Jura lake in its lower portion, and an Alpine lake in its upper portion, while its middle portion is a union of the two; in the Lake of Lucerne the two basins intersect each other, giving to the whole lake the form of a cross.

Of the three kinds of lakes mentioned above—the border-lakes, valley-lakes, and mountain-lakes, the last will be the first considered in detail. A large number of lakes are found on high Alpine ridges, at a height of from 4000 to 8000 feet, which are consequently called high mountain-lakes. They are generally small, few being found of more than from three to four miles in circumference, dark-green, blue, or lightish-grey in colour, and often having great clefts in the bottom of their basins, through which subterranean streams sometimes flow. The glaciers descend to their surface, and thus they receive the snow and glacier-water directly from them, and they are also the first to receive the deposits from avalanches and falling stones. The Daubensee, near the Gemmi Pass (7236 ft. above the sea), the Todtensee (6872 ft. above the sea), in the neighbourhood of the Mayenwand, the Weissensee, in the Stubach Valley (7485 ft.), the Oschenigsee, in Carinthia (7623 ft.), the Goldzechsee, in

the Hohen Tauern (8194 ft.), are such lakes, and have the oval form which is peculiar to many of them. These lakes lie for more than half the year under a covering of ice and snow. Some of them are covered as early as October, and do not thaw until July; many of them freeze to the very bottom, turning into a coherent lump of ice which never thaws throughout the whole year, as, for example, the small lakes on the Col de la Fenêtre, at a height of 8482 feet, and those east of the Rawyl Pass, at a height of 8460 feet; they are called ice-lakes. Their characteristic is, with few exceptions, solitude, in the bare, desolate region of the High Alps. They harbour no fish, their shores are adorned by no vegetation. Sometimes they are enclosed by chains of rock, from which the peaks rise boldly, sometimes they disperse into damp, dirty meadows. In the latter case many of them, with their stagnant muddy water, resemble marshes or morasses. When they lie as low down as the region of trees, their banks are bordered by dark firs or groups of stone-pines. The names by which they are known often indicate their character, such as, the "Todtensee" (Dead Lake), "Hexensee" (Witch Lake), "Trübsee" (Gloomy Lake), &c.

One kind of ice-lake, called glacier-lakes, is formed when a glacier, which is moving down a main valley, meets the glacier which has come from a collateral valley and overspread the floor of the main valley; the stream of the latter being thus obstructed is formed into a lake. Lakes of this kind are always enclosed on one side by lofty walls of ice, from which huge fragments sometimes break off and roll on to the lake in the form of blue icebergs. These lakes are also formed by large masses of ice breaking off from the glaciers, and lying on the high flanks of the valley, as in the Val de Bagne, at Martigny, where such an event happened in the breaking up of the Gétroz Glacier. Disastrous consequences have sometimes resulted from the sudden bursting of the ice-dam of these lakes. The contents of the lake, becoming a wild torrent of muddy water, hurl

themselves down with fearful force towards the valley, devastating the whole district through which they pass, and piling up, here and there, huge heaps of *débris*. The outbreak of the glacier lake, in the Val de Bagne, in 1818, and that of the Vernagt Lake, in the Ötz Valley, in 1845, were of this nature. The enclosing walls of these lakes are sometimes rendered firmer by moraines. The Märjelensee, on the Great Aletsch Glacier, and the Mattmarksee, in the Saas Valley (both in Switzerland), the Langthal Eissee at Gurgl, in the Ötz Valley, and the Weissensee, in the Stubach Valley, in the Tauern district, are existing glacier lakes.

High mountain lakes are often found on the ridge of a mountain pass, as on the St. Gothard, the Majola Pass, and on the Reschen Scheideck, and in that case they are the sources of streams. When thus situated, or when lying in the pasture-districts of the Alps, their banks show a little more life, in green meadows, Alpine cattle coming to drink, herdsmen's huts, &c. In the first case, the road over the pass usually lies near it, and the shelters and hospices for travellers stand on its shores. The wealth of such small lakes which the Alps possess may be imagined, when it is stated that the high plateau of the St. Gothard contains twenty-seven of them, and the little canton of Uri, forty. They are fairly numerous also on Monte Rosa and Mont Blanc, but south of the latter, to the sea-shore at Nice, they disappear almost entirely from the mountains. They are found in great number, as has already been shown, in the high Alps and passes of Switzerland, and increase in number on the border of the Grisons and Tyrol. In this place they begin with the four lakes near the head-waters of the Inn, in the Upper Engadine, and are continued through a great portion of the eastern chain of the Alps.

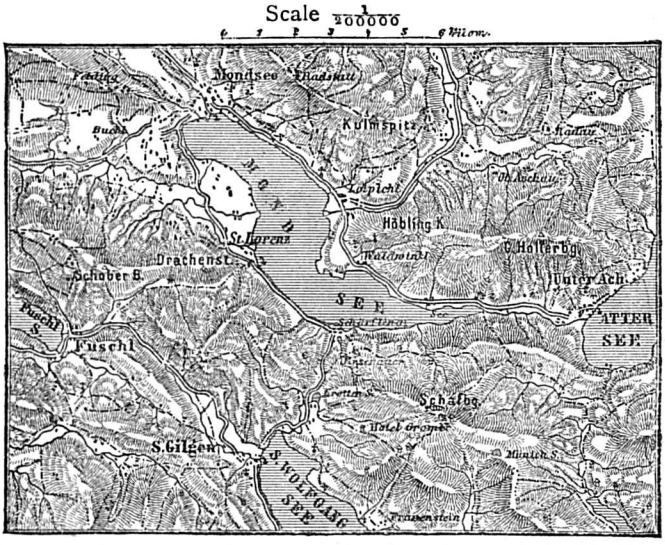
The large lakes, that is, the valley-lakes, and more especially the border-lakes, are of far greater importance to man than are these small Alpine lakes. The large lakes are not found through-

out the Alp country; the western wing contains very few, and the longer eastern wing has no great number on its southern side, indeed, only a few between Monte Rosa and the Etsch, but on the northern side towards Germany, in Switzerland, in Bavaria, and the Austrian Salzkammergut, a considerable number are found. The great attraction exercised by the lakes probably lies in the contrast which they present, with their varying, ever-moving surface, to the motionless masses of the "everlasting hills" which surround them, as well as in the varied beauty of their shores, changing from stupendous wildness or sublime grandeur to soft, idyllic loveliness, and in the softness of their climate and their luxuriant vegetation.

The border-lakes form a long girdle in the north of the Alps from the Lake of Bourget, on the west, to the Traunsee, in Upper Austria, and a second in the south from the Orta Lake to Lake Garda, in Italy. The northern girdle is not only much longer than the southern, but the number of lakes in the former is much greater. Following the Lake of Bourget is that of Annecy, then the Lake of Geneva, the Neuenburg, Murten, and Biel Lakes, the Lakes of Thun and Brienz, Sempach, Baldegg, Hallwyl, the Sarner Lake, the Lake of Lucerne, the Lakes of Lowerz Zug, Zürich, the Greifen and Walen Lakes, Lake of Constance, the Alp Lake, at Immenstadt, the group of Lakes of the Lech, at Füssen, the Ammer Lakes, at Murnau, the Staffelsee, Tegernsee, Schleiersee Chiemsee, the Waginger Lake, the Traunsee, the Wallersee, the Lakes of the Salzkammergut, the Zeller, Mond, Atter, and Traun Lakes, with the Fuschel Lake, and Lake of St. Wolfgang.

At this point, towards the east, the lakes come to an end, until far away in Hungary two large isolated, out-lying lakes are met with, the Neusiedler Lake, and Lake Balaton. The southern girdle of lakes includes the Orta Lake, south-east of Monte Rosa, the Lago Maggiore, the Lago di Varese, Lakes Lugano, Como, Iseo, Idro, and Garda. At a considerable dis-

tance to the east, small lakes occur again, but are deeper among the mountains, such as the Lago di Santa Croce, south-east of Belluno, and the Lago di Cavazzo, in the bend of the Tagliamento. The Lago di Viverone, at Ivrea, must also be included among the outlying lakes. All the lakes mentioned above, both northern and southern, lie in the limestone district, only the Lago Maggiore and the Lake of Como penetrating to the primitive mountains; they, however, are also for the most part surrounded by more recent formations. The zone of primitive



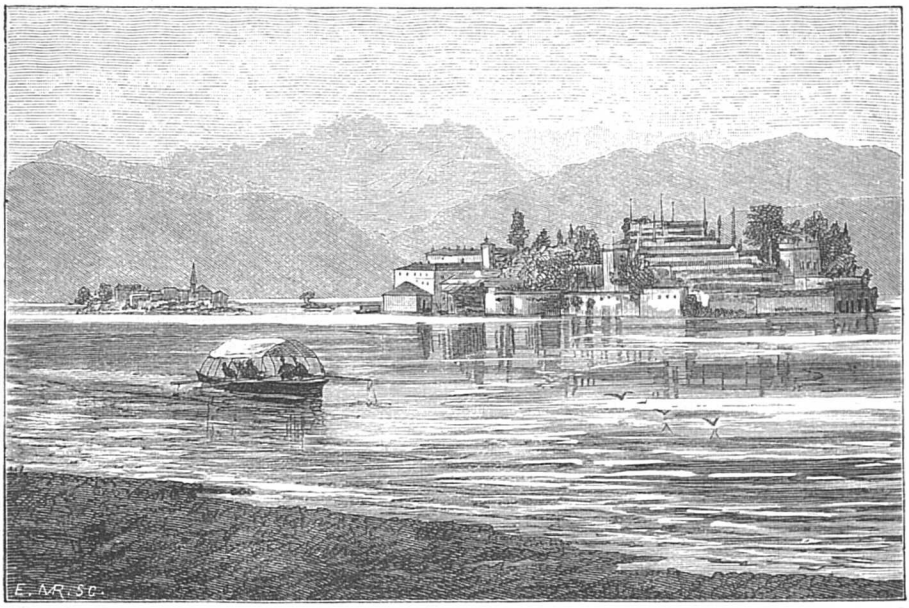

The Mond See in the Salzkammergut.

rocks is entirely destitute of large lakes, with the striking exception of Carinthia, where the large valley lakes of Millstatt, Ossiach, and Wörth are found.

With regard to the height at which the lakes lie, a decided difference is found between the northern and southern lakes, the southern lying much lower than the northern. The southern lake, which has the highest situation, is Lake Orta, 1220 feet above the sea, the lowest, Lake Garda, 153 feet. Among the most northerly the lowest is the Lake of Bourget, which is not much lower than the highest of the southern lakes, the highest

is the Walchensee, 2594 feet, that is, more than double the height of Lake Orta. The mean height of the thirty-one largest northern lakes is 1654 feet, that of the eight southern lakes named above is 786 feet. Of the northern lakes, sixteen lie at a height of from 1300 feet to 1640 feet, seven between 1640 feet and 1960 feet.

The depth of the Alpine lakes is a particularly interesting



Lago Maggiore.

subject. The natives of the Alps think that most of them are bottomless, or at least are as deep as the mountains are high. Thus the boatmen on the Traun Lake ascribe to it a depth equal to the height of the Traunstein, which towers above it. It is a remarkable fact that so little information respecting the relative depth of the lakes is available in spite of the large number of scientific travellers who annually visit their shores, and devote themselves to mountain researches. Guide-books and hand-books vary considerably on this point.

The lakes of the Salzkammergut have been carefully sounded by Simony, and more recently the Swiss lakes have received some attention in this respect; the lakes of Upper Bavaria have also been accurately measured. It may be stated generally that the steeper the surrounding mountains are, the deeper are the lakes. Thus the southern border-lakes of the Alps are deeper than the northern, since the mountains have a steeper slope on that side. The Lago Maggiore, the surface of which lies 645 feet above the Adriatic, has a depth of not less than 2800 feet; the Lake of Como, in its deepest part, is nearly 2000 feet deep; Lakes Garda and Iseo are not quite so deep, but still descend far below the level of the sea. The mean depth of the large lakes on the northern side is found to be 564 feet, while that of the five southern lakes which have been measured (Maggiore, Iseo, Lugano, Como, Garda) is 1530 feet, a depth reached by only one of the northern lakes, the Hallwyler.

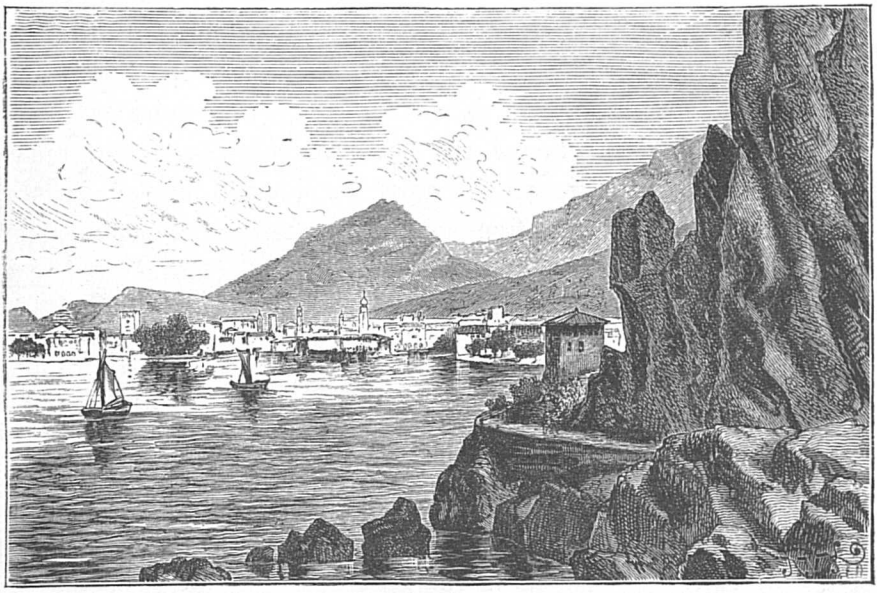
If the area of the lakes is compared with the depth, it will be seen that in both respects there is a diminution from west to east.

Herr Geistbeck has pointed out also that the large valley-lakes are of great depth, and of comparatively small superficial area, but the great basins of the outlying Alps are of large size and comparatively slight depth. The mean breadth and depth of the lakes stand in inverse ratio to one another.

The number of the Alpine lakes has not yet been exactly ascertained. An old estimate by Saluzzo gives the total number of lakes as 440, but this is far too small: the number must certainly exceed 4000. The area of the lakes, on the other hand, has been accurately ascertained by Strelbitzky, who, however, excludes the small lakes. According to his estimate the area covered by the lakes of Switzerland is 488 square miles, by those of Germany 237 square miles, by those of Austria, including the Neusiedler Lake and Lake Balaton, 498 square miles, by

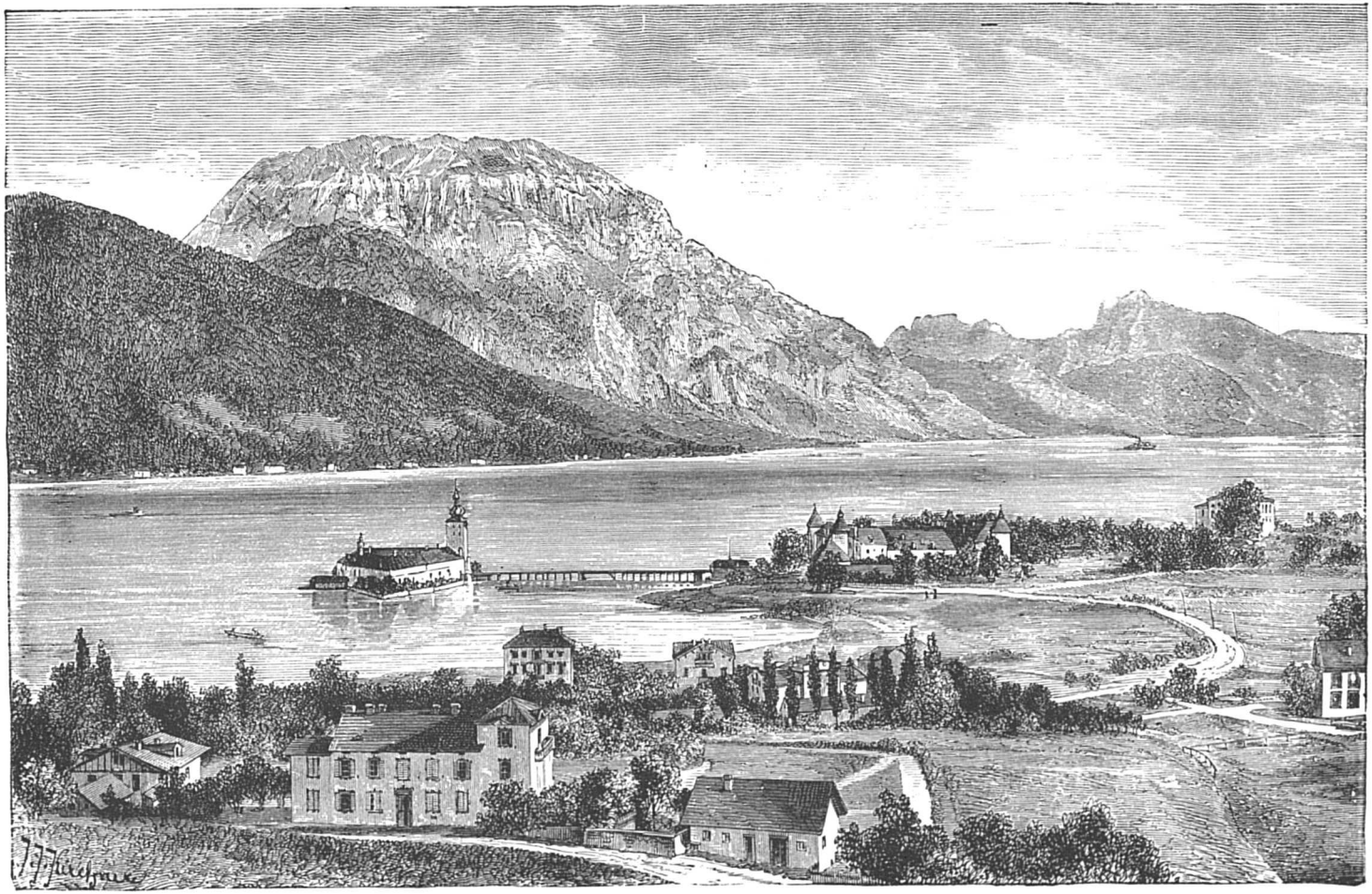
the lakes of Italy 369 square miles, and by the lakes of France 125 square miles, giving a total area for the lakes of the whole Alpine district of 1717 square miles. This, however, is considerably too small.

The relations of the Alpine lakes to the rivers are very varied. Many of the mountain lakes discharge themselves by no visible stream ; some of them at the time of flood send their overflow



Riva on the Lago di Garda.

temporarily to another river district, other high mountain lakes are, as has been shown, river sources. The larger lakes, however, are all connected with some river, and the largest, the Lakes of Geneva and Constance, form a passage for the largest rivers, but in the Alps lake and river are not so closely connected, especially as regards their relative size, as the consideration of these particular instances would suggest. Of the numerous rivers which fall into the Po, in only four (the Ticino, the Adda, the Oglio, and the Mincio) does a lake occur ; the larger rivers of the Bavarian plateau, the Lech and the Isar, as well as the



The Traun or Gmundner Lake.

largest of all the Alpine rivers, the Inn, pass through no lake, while sometimes far smaller streams are connected with large lake-basins. Thus the Starnberg Lake, the Chiemsee, the Waginger Lake, the Wörth Lake, &c., are fed by comparatively small streams. The Atter Lake, which is filled by the Ager, is twice the size of the Gmundner Lake, which is formed by the much larger river the Traun. Indeed, it may be said that the relation of lake and river is special to each case, though it may be asserted of all that the river-lakes act as regulators of the rivers; they receive the overflow of the upper streams, and moderate the flow of the lower course. They also act as filtering beds ; the rivers enter them dirty, laden with mud and rubbish, they leave them purified and clear.

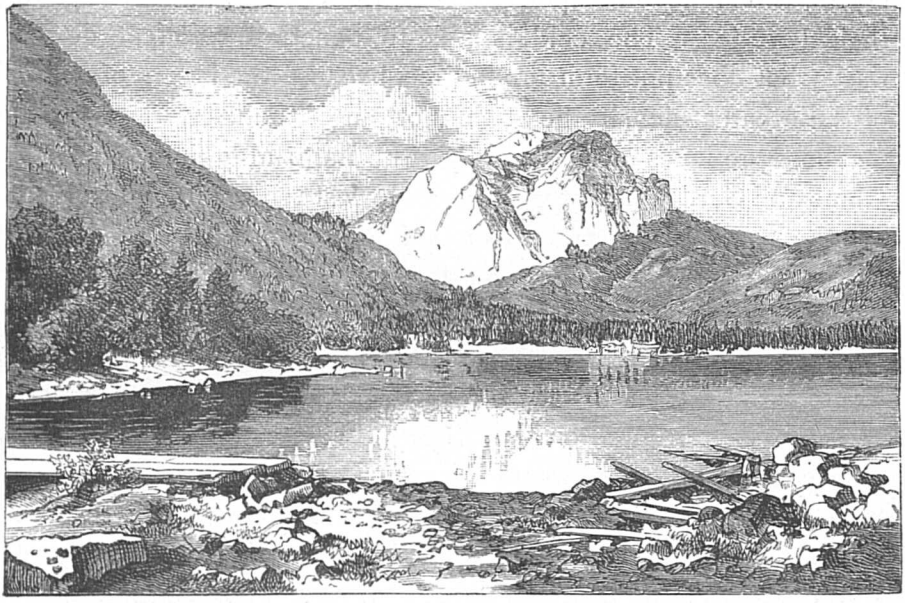
The colour of the lakes also demands some attention. Wherever there are great natural bodies of water, they are seen to be more or less coloured. Setting aside the colour of the sea, the waters of the land are found to vary from light yellow to coffee-brown, green or blue; and in addition to this diversity of colour a vast difference in its degree of transparency may be observed. In some waters objects may be discerned at a great depth, while in another stream nothing is visible beyond a depth of three or four feet. The streams and lakes of the plains are generally much less clear, and more frequently of a yellowish colour, than those of the mountains, in which green and blue colour prevails. The greater part of the water of the Alps, either standing or running, is green or bluish-green, more rarely blue, though the latter is sometimes found bright and clear. Lake Garda, the Lake of Geneva, and the Achen Lake are famed for this beautiful blue colour, as the Königsee and the lakes at the source of the Inn are famed for their fine green hue. This colour also appears in shallow places, in the upper course of the mountain streams, but they are often very muddy when they carry down much of the detritus from the rocks, as is frequently the case with the rivers which flow from the limestone

mountains. The streams which flow from glaciers show this thickness most constantly; it is sometimes so excessive that the water appears quite milky. If the water enters a large lake, in which the fine matter has time to deposit itself, the stream emerges on the other side as green and clear as the other mountain rivers. The colour of water has been the subject of much study and research, without the question being finally decided. Bunsen explained that all clear water appears blue when light is passed through a compact body of it. Simony, on the other hand, showed that the fundamental tone of the colour of the Alpine lakes depended exclusively on the matter which the water contained, partly in solution, and partly in suspension. It is not the perfectly pure water which has the finest colour, but that which contains a small amount of impurity. Organic particles, added in considerable quantity, colour it dark yellow to brown. Streams which come from large forests are of a brown colour, in shallows amber, or almost golden yellow. This yellow water, being mixed with clear blue water, gives a green colour.

This explanation may serve for many cases, but does not seem at all to cover others, especially those, where a stream composed for the greater part of melted snow and ice, from the first appears green, where it is at all deep. In the case of sea-water, Tyndall's researches have shown that the green colour appears where there is a large quantity of matter in suspension, because the layer of water between this and the eye is not thick enough to absorb the green rays. Water, as is well known, when shallow, appears colourless, and takes from the light, first the red rays, then the yellow, then the green; the thinner layers of a deep mass of water, which by itself appears an indigo blue, allow the green rays to pass through them without being absorbed, and the suspended particles give it a green colour, because they reflect the light nearer the surface. Whether this explanation also serves in every case for the Alpine lakes cannot be decided

here. It may be remarked, in conclusion, that the condition of the sky has a very decided influence on the colour of the lakes. The same lake which appears in bright sunshine to be of a brilliant emerald green, may, under a lowering sky, assume a dull grey colour, and before the bursting of a storm become almost black.

The temperature of the upper layers of water in the large lakes



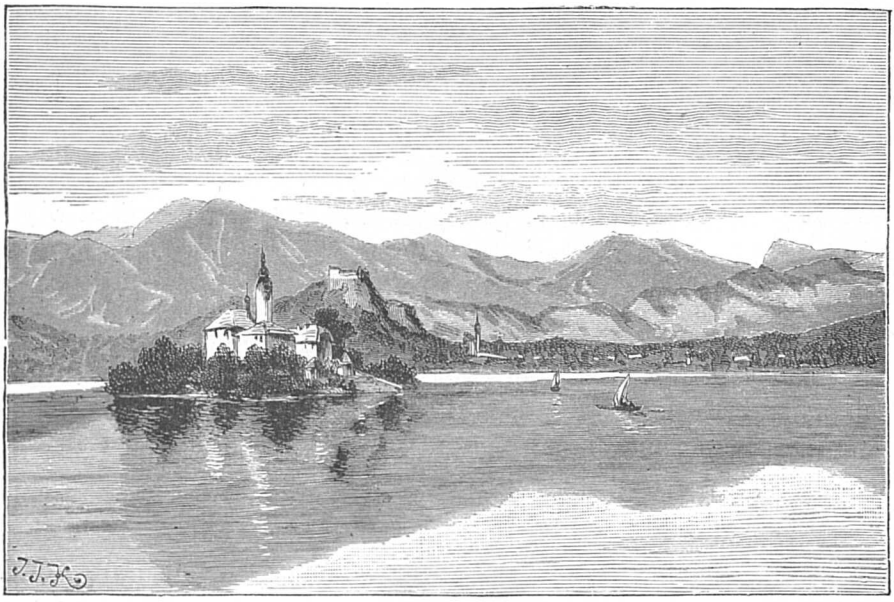
The Langbath See in Upper Austria.

is comparatively warm, especially in the lakes of Upper Italy. Besides these the Lake of Geneva and the Lakes of Carinthia are noted for their high temperature in summer. At that season Lake Wörth, at Klagenfurt, rarely has a temperature below 22° C.; the highest temperature observed in Lake Garda is 30° C. The lower strata of water show a lower temperature than the upper, and in the lowest the thermometer sinks to 4° C. or less. The following temperatures were taken by Pfaff in 1880, in the Achen Lake (Tyrol); at the surface 14·4° C., at a depth of 196 feet 3·5° C., at the bottom 394 feet, 2·5° C.

The liability to freeze, of the large Alpine lakes, depends on the different temperature of the layers of water. Water, as is well known, reaches its greatest density at a temperature of 4° C. When the air begins to be cooler in the late autumn, the upper strata of water begin also to grow cold. This cooling proceeds downwards, till the entire mass of water reaches the temperature of its greatest density; then ensues a cooling of the superficial layers, which lie one upon another, from 0° to 4° according to their densities. The cold is able to penetrate 350 feet downwards, but does not form ground ice, because the layers of water of the greatest density lie at the bottom of the lake.

The large lakes of Upper Italy—the Lago Maggiore, Lakes of Como and Garda—never freeze; the lowest temperature observed on the surface of the last named was 3·75° C. The severe winter of 1879-80 called attention to the freezing of the lake-basins in the northern district of the Alps. At that time the Lake of Zurich was frozen from the 22nd January to the end of February; the Bieler Lake was frozen for seventy-five days; traffic was interrupted on the Murten Lake for eighty-two days. The careful observations of M. Forel show that among the Swiss lakes, the flatter inland basins are the first to freeze, such as the Murten, Biel, Sempach, Baldegg, Hallwyl, Greifen, and Pfäffik Lakes; the next are those of Zurich and Zug, and after these the Neuenburg Lake, and Lake of Constance, and then very rarely the Lakes of Lucerne, Thun, and Brienz. The Lakes of Geneva and Lucerne can be only partially covered with ice, and the Walen Lake, so far as is known, entirely withstands frost. The Neuenburg Lake and Lake Constance freeze only about once or twice in a century. Lake Constance was frozen over in 1880 from February 7th to 20th; in ordinary years, only the part between the two Lindau bridges is frozen, and, nearly every winter, the shallow Untersee. The lakes of the Austrian Salzkammergut were also frozen in 1880, but this occurrence is as rare with them as with the Swiss lakes. The Traun Lake,

for instance, has only been completely frozen over six times in the last 400 years. The case of the lakes of Carinthia is quite different, since they freeze very frequently, if not annually, and remain frozen for a longer time. The longest time of frost observed in the Wörth Lake is 109 days, the average seventy-one days, and the shortest twenty-two days. The difference of the lakes in this respect may be explained, not only by variation of lati-



The Veldes See in Carniola.

tude, but also by the influence of depth, elevation, the steepness of the banks, and shelter from the wind. The same lake will, at different times, resist the action of frost in proportion to the amount of sunshine it receives during the day, and of mist and cloud during the night. Great quantities of ice are taken to the large towns from the Alpine lakes which lie near to the railway-stations.

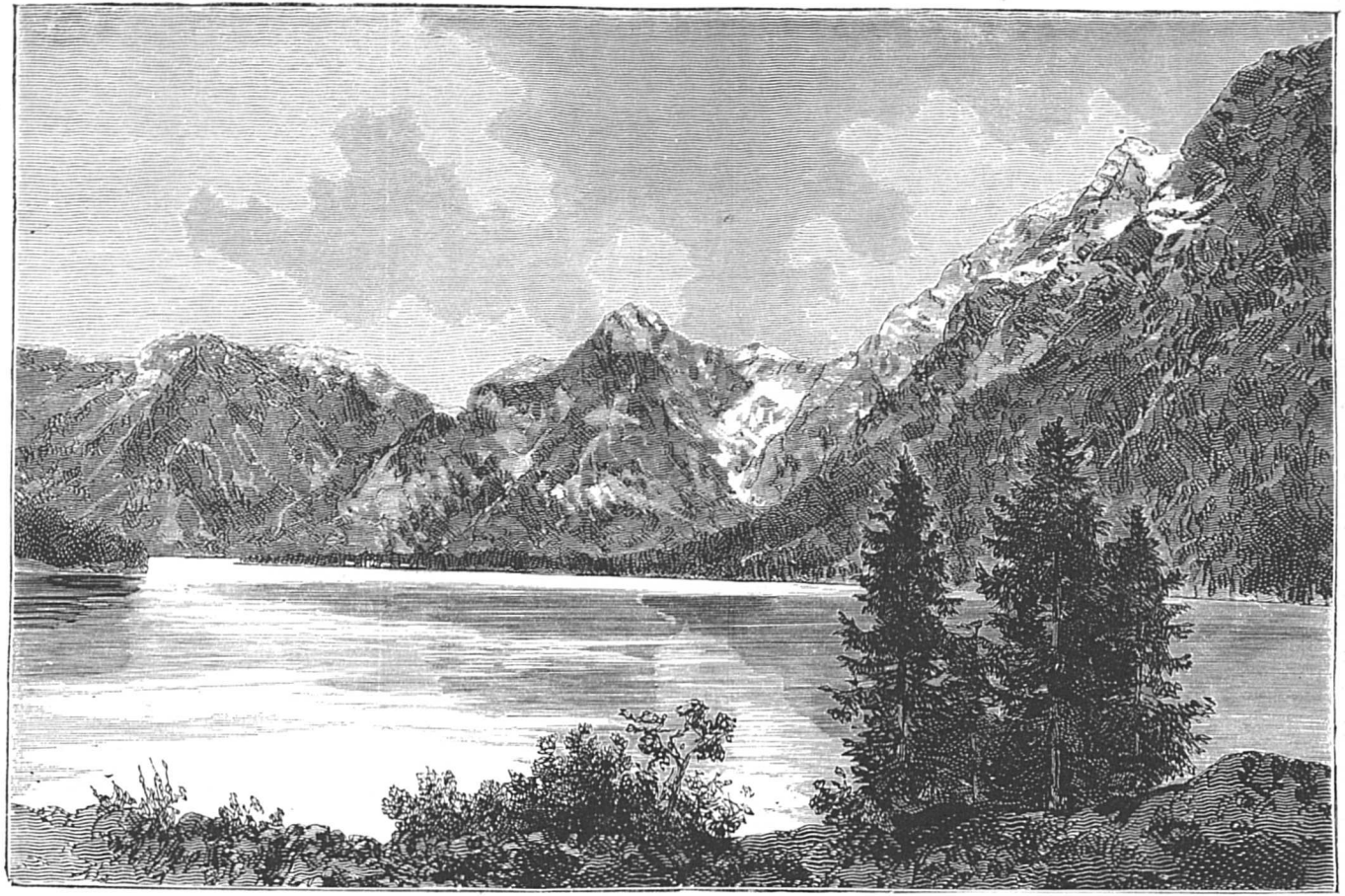
One peculiarity of the Alpine lakes is the occasional local swelling of their waters. All long and narrow lakes,

over which atmospheric changes pass in an extraordinarily rapid and powerful manner, frequently exhibit sudden fluctuations of level, which can only be explained by variations in the pressure of the air. This is frequently seen in the Lake of Geneva and Lake Constance, the rising of the water being observed first in one place, then in another. In these local swellings of the water it sometimes rises suddenly from a few inches to three feet above the surrounding body of water. This occurrence cannot be explained by the sudden swelling of subterranean affluents, for it is often seen at the foot of mountains composed of hard rock, which certainly do not conceal any important streams in their depths. It has been demonstrated that the swelling of the Baltic Sea, which greatly resembles that of the Lake of Geneva, is closely connected with the condition of the barometer. When the pressure of air decreases, the surface of the sea begins to rise, and when the barometer rises again, the surface of the sea sinks.

It will be evident that currents cannot occur in lakes, with the regularity that they have in seas; they may, however, be observed in the larger lakes, and are produced partly by difference of temperature of the water, and partly by wind. A peculiar current, called "Corrivo," is seen on Lake Garda, when the wind, after having driven the water in one direction, falls, and allows the water to flow back to its former level.

A smooth, apparently motionless stripe of water is seen on the surface of Lake Constance, more particularly between Ermatingen and the island of Reichenau; this is a current. The water of the lakes is sometimes moved by the wind into waves, which in storms reach a great height. When the lake-wind (Föhn) blows, waves nearly eight feet high have been seen on Lake Constance. Lake Garda is often visited by terrible storms, when its waters rage and roar like the waves of a stormy sea.

All the Alpine lakes, especially the border-lakes, have their local wind, which will be referred to when the climate of the



The Königsee.

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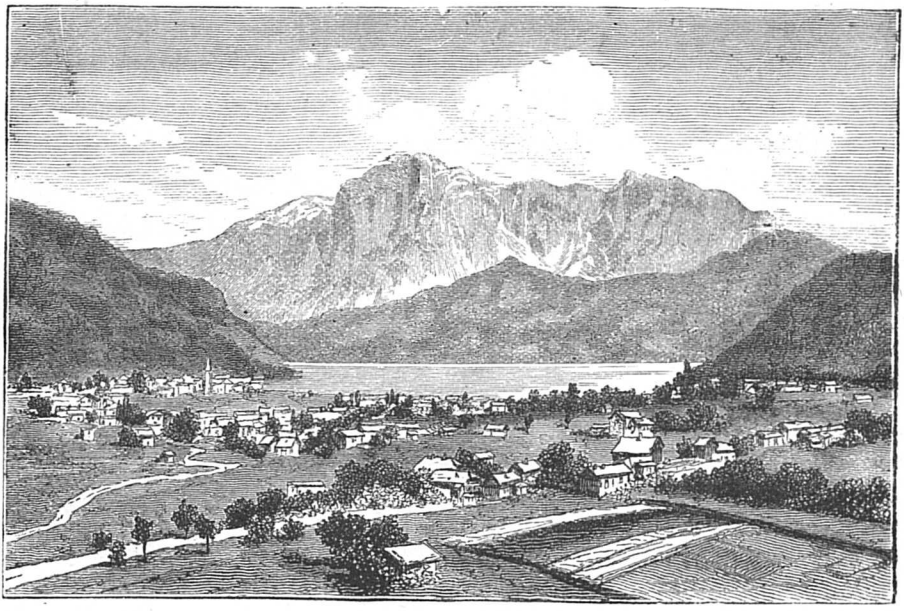
Alps is considered. One of the most important subjects connected with the lakes remains to be spoken of, that of their origin. The origin of barrier-lakes by the formation of an obstruction in the course of a stream, either by the fall of rocks from the mountains, or by the gradual deposition of *débris*, has already been described, as well as that of the glacier-lakes, formed by the overlapping of a main glacier and a collateral glacier. Many lakes, lying deep among the mountains, owe their origin to the washing away of the softer rock, as in the case of the Hallstätter Lake, the Königsee, and other lakes in the Salzkammergut, which is rich in beds of rock salt. The lakes of Upper Italy, the beds of which lie, as has already been stated, below the level of the Adriatic Sea, have hitherto been considered as being separated portions or remains of the Adriatic sea, which was formerly of far greater extent, and covered the whole of the Lombardo-Venetian plain. The fact that the remains of marine animals are still found in Lake Garda seems to support this theory. More recently, however, it has been shown that the fossils found in Lake Garda, the *Blennius vulgaris* and *Palæmonetes lacustris*, have also been observed in the crater-lakes of Albano and Nemi, as well as in true inland lakes; their presence in Lake Garda therefore cannot be taken as a proof of its having formed part of the sea.

By far the greater number of the Alpine lakes are not barrier-lakes. They may be divided, according to their origin, into excavated basins, in which the scooping out must be due to some external agent, and tectonic basins, which have originated in movements of the earth's crust, and have some connection with the internal composition of the rock. The question of the origin of the lakes thus has close relations with the views held as to the origin of the valleys. Geologists have held various views regarding both; all, however, agree that lakes are only temporary incidents in the formation of valleys, and in the history of our planet. Their depth, the nature of their outlines,

and the form of their beds are all temporary, and, like the peaks of the mountains, are undergoing a continuous process of transformation. As soon as a lake becomes constant; that is, when its surface has attained such a height and breadth that an amount of water, equal to its supply, is carried off by evaporation, its affluents begin to fill it up with the *débris* and detritus which they bring with them.



Old Aussee and the old Aussee Lake.

At least three-quarters of the rocky matter brought down by the rivers to the lakes are deposited at the river-mouth, but the finer silt remains suspended in the water, and sinks very gradually, being carried meanwhile towards the outlet of the lake, and helps to form the outlet deltas. Thus the river-lakes are filled up at both ends. This work of the rivers is supplemented by the decomposing action of the atmosphere, the soaking of the rocks, and the fracturing power of the ice, the chemical processes of solution, and the wind, by all of which the rocks sur-

rounding the lakes are by degrees loosened and shattered; fragments of rock are carried by their weight to the shore of the lakes, often, indeed, into the lakes themselves. The lake helps, by the constant lapping of its waves, to destroy its own shores, and provide material for the formation of banks and terraces. Many of the outlying lakes owe their destruction to other agents also. The shallow, marshy banks of these lakes are often overgrown with shore plants, the withered portions of which sink to the bottom of the lake, and pile up an ever-increasing layer of decaying vegetable matter, while reeds, rushes, flags, and other water-plants growing on the original bank, gradually advance more and more into the lake, their thick masses of root spreading farther and farther along the bottom. From above, the dead leaves and stalks of lake roses, ranunculuses, and duckweed, annually fall to the bottom, and the confused mass of vegetable remains grows thicker, and, becoming entangled with the roots which penetrate it, forms at length a coherent felt-like mass, resting upon a bed of mud; marsh-trefoil and horsetails, and especially *Sphagnum* and *Hypnum* grow upward from this floating mass of vegetation, while its lower portion being cut off from contact with the air, gradually passes into peat. Millions of living organisms herd among the decaying vegetable matter, their bodies, when dead, sinking to the bottom, and still further raising its level.

These numerous combined agencies show that traces of the process of extinction of the lakes, even in historic times, may plainly be observed. The Lech, the Isar, the Inn and the Salzach, all formerly passed through splendid lakes, on the steep border of the mountains, at Füssen, Tolz, Rosenheim, and Salzburg, where desolate morasses alone remain to indicate the position of these departed beauties.

Peter Anich's map of Tyrol, published in 1774, contains over a hundred lakes, which have since disappeared. The names of many of the dry plains among the mountains, such as Seeboden,

Seebodenalp, Seealpboden, Seemättli, Seewies, Plaine des Iles, &c., prove that lakes formerly existed at these places. Indeed, it seems certain that most of the smooth plains in the mountain and Alp region have once formed the basins of lakes. The gradual process of extinction can be seen in those lakes still existing, as well as in those that are now dry. There is no lake in the Alps which has not at one time been larger than it now is. Lake Constance once extended as far as Balzers, near Sargans, in the upper valley of the Rhine, and stood at least 660 feet higher than at the present time, forming with the Walenstatt Lake, and the Lake of Zurich, a sheet of water which touched the Jura. The Bergkuppe, which stands east of Riva, on Lake Garda, was formerly an island, but now stands high and dry in consequence of the deposition of alluvium by the Mincio. The Chiemsee affords one of the most remarkable examples of the filling up of a lake in historic times. The old Roman road, and more recent high-road from Rosenheim to Salzburg, makes a great circuit, running close to the foot of the mountains, while the railway cuts across the moor to the south of the lake by the shortest way. It is evident that when the road was made, it was impossible to take it in a straight line across the Achen delta, because the marshy land and a part of the lake cut through a tract which is now firm land.

## CHAPTER XII.

### THE ACTION OF EROSION AND WEATHERING.

In previous chapters, frequent allusion has been made to the stupendous effects of erosion and weathering, agencies which are incessantly at work altering and transforming the face of the Alpine country. Some of the most striking effects of these agencies will now be considered, more particularly landslips, the "Karrenfelder," and the earth pyramids.

An unbroken stream of fragments of detached rock descends from the upper parts of the mountains to the lower, but it is only when rocks of great size descend quickly or suddenly that they attract any attention. These occurrences are among the most terrible on earth, and the remembrance of such a catastrophe endures for centuries, no event being more calculated to act on the imagination of the people. Precipitous or overhanging rocks, which hang above peaceful meadows, suddenly become loosened, and slip down the slopes, raising in their fall a cloud of dust, like the cloud of ashes from a volcano; a terrible darkness spreads over the once smiling valley, and the trembling of the earth, and the crashing together of the falling rocks, is all that can be known of the misfortune. When the cloud clears away, heaps of broken rock and rubbish are seen to spread over the meadows and fields that just before were so green and fertile. The stream in the valley is blocked up, and turned into a muddy lake; the rocky flanks of the mountain have lost their old form, and expose a fresh surface, where the huge mass, like an entire mountain, has fallen away.

The chief cause of these landslips is, first, the weight of the

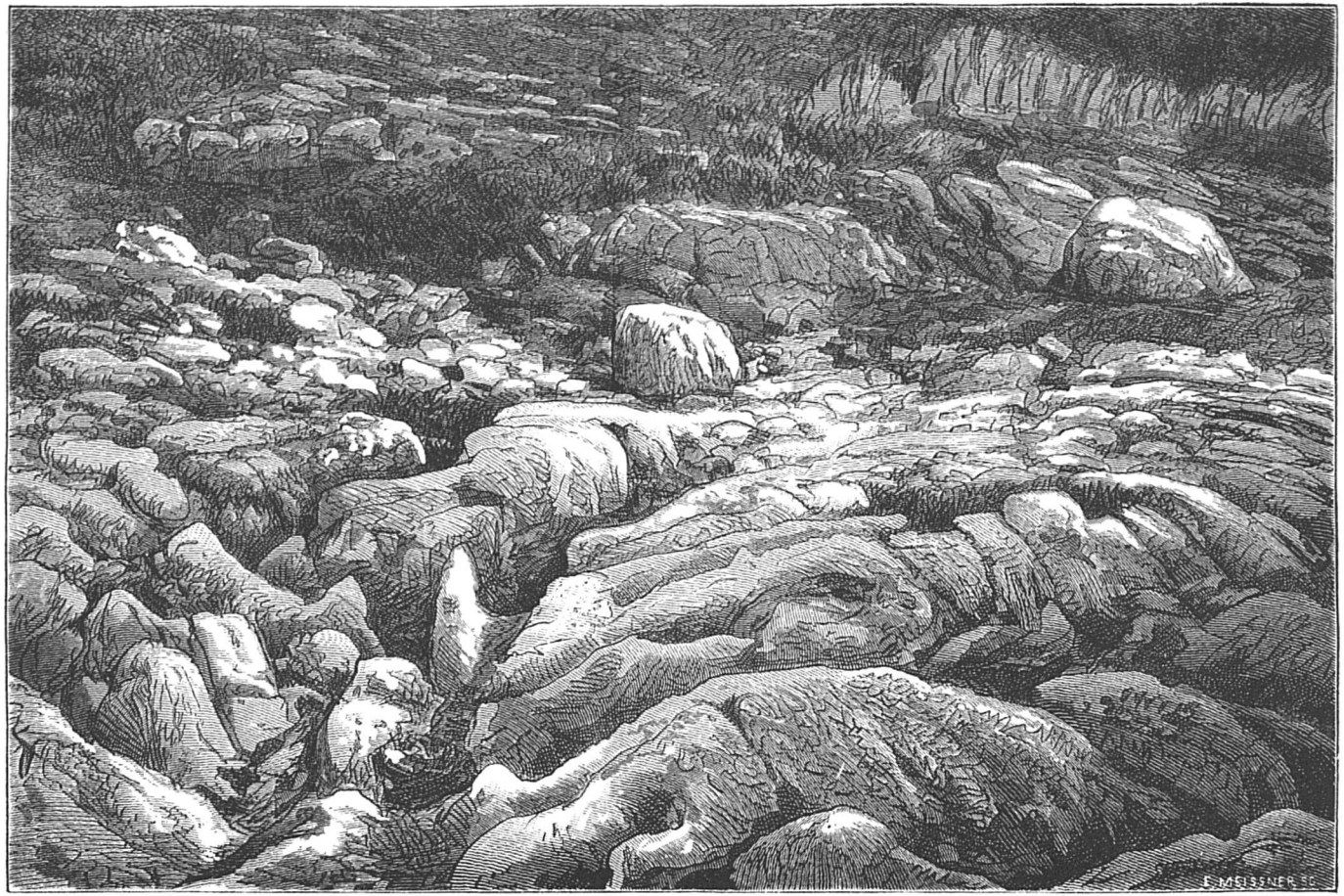
rocks, and next, weathering in the widest sense of the word. Every kind of rock, in a definite position, has a fixed maximum slope, which may not be permanently exceeded, without its being loosened from above and gradually broken off. The maximum permanent slope may be exceeded in consequence of undermining, or it may decrease through alteration of the material itself, until it becomes flatter than the slope of the mountain-side. The mountain-side may be undermined either by rivers and brooks, which penetrate it, or by the reckless work of man in mining, quarrying, road-making, &c. Alteration in the material of the rock itself may occur from a diminution of the internal friction, and an increase of weight, both being the result of continued saturation, by diminution in firmness in consequence of mechanical and chemical weathering, that is through frost, variations of temperature, roots of plants, by dissolution, or decomposition of individual constituents of the rock, &c. A third cause may be severe earthquakes, a fourth the internal tension of the rocks, and their continual changes by erosion and weathering. Except in the case of unusually severe earthquakes, it will be seen that landslips are the result of circumstances, which require for their development not weeks nor months, nor years, but centuries. The moment at which the fall occurs, is that when the last link is severed, which held the fallen mass to the mountain-side. The severence is facilitated by the action of the rain channels, and the melting snow, and consequently landslips occur more frequently in September and April than at any other time.

In the Alps, as well as in other high ranges of mountains, there are few valleys in which evidence of landslips is not met with. The greatest catastrophes of this kind which have occured within the Alps in historic times, are mentioned by chroniclers and historians. The Roman town of Tauretunum, which must have stood on the bank of the Lake of Geneva, at the foot of a spur of the Dent d'Oche, was completely destroyed

by a fall of rock, in the year 503, and the great masses may still be seen rising in hills from the waters of the lake. The most important landslip in Austria lies in the valley of the Adige, in the Italian Tyrol, between the mouth of the Lana and the village of San Marco, and is called by the local population the Slavini di San Marco. It is said to have occurred in the year 883, and the bed of the Adige below was dry for some time after. In the year 1248, four villages at the foot of Mont Granier, near Chambéry, were buried beneath huge masses of limestone, which have since then been much washed away by water, and transformed into hills; numerous small lakes, which are called *abîmes*, are found in these old remains, which are now covered with fertile fields. One of the most terrible landslips recorded occurred on January 25th, 1348, at Dobratsch, in the Gailthal Alps. The rock split, the lake near the top sank and disappeared, and the south-western portion of the mountain was hurled down, burying ten villages, three castles, and seven hamlets, and the Gail Valley, being dammed by the fallen rocks, became a lake, through which the river broke a path with great difficulty. In 1597, Simplon, in Switzerland, was destroyed by a landslip. Perhaps the most destructive fall that ever occurred in the Alps was that of the Cento mountain, in 1618, which entirely buried the little town of Plurs, above Chiavenna, in the Upper Bergell, and killed 2430 persons. Two of the five horns of the Diablerets broke off, one in 1714, the other in 1749, the high pasture-lands lying near were piled up with rubbish to a height of 330 feet, the course of the Lizerne was obstructed, and formed three lakes, which still remain, the Lacs de Derborence. In the same way the Bernina, the Dent du Midi, and the Rhigi, have covered huge tracts of cultivated land with their *débris*. No catastrophe of this kind, however, has left such an impression on the memory of the inhabitants of the mountains as the landslip in the Rossberg, north of the Rhigi, which occurred in September, 1806, and is known as the Goldau land-

slip. In this great fall the villages of Goldau, Röthen, Busingen, and Lowerz were buried, together with 457 persons. The Calanda has for centuries been notorious for its repeated landslips above Felsberg, the most terrible of which took place in the year 1807. In 1850 Alt-Felsberg was entirely destroyed by a landslip, and the surviving inhabitants moved farther to the east, and established a more secure settlement at Neu-Felsberg. The most recent great landslip was that of Elm, in Glarus, in September, 1881, when over 13,000,000 cubic yards of rock fell into the valley, killing 114 persons. Very serious landslips had occurred before this in the Canton Glarus, in 1593, 1594, 1686, and 1843 on the Glärnisch, in 1762 and 1763 at Ober-Urnen. An inquiry into the landslips of prehistoric times would give a far greater number.

The limestone plains among the high mountains acquire a very peculiar character from the chemical decomposition caused by the water deposited on them, and also partly by erosion, especially where the snow lies for a long time and thaws very gradually, and most commonly on slopes of softer rock near the snow-line, and on flat peaks. Among the limestone Alps, at a height of 5250 feet, or more frequently from 6230 to 8530 feet, are found, aside from the frequented passes and inhabited Alpine pastures, bare plains of rock, often three or four miles in length, and lying almost horizontally, which are so furrowed and channelled that they look as if a rough sea with its rolling waves had suddenly been petrified, leaving what appears like an inextricable network of crested waves. These plains are the "Schrattenfelder" or "Karrenfelder," called by the Romanche inhabitants "Lapiaz." Sometimes they are so entirely split up and worn by deep channels, that it is impossible under any conditions to find a way over them, for the rocks between these clefts run out close together like small dykes, then suddenly break off, and are intersected by cross-channels; sometimes they look like crests, the separate peaks of which are broken off at different



The " Karrenfeld," on the Wiesalpe (Dachstein Group).

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heights; the whole plain looks as though it had been hacked and shaved and sawn and chipped by gigantic tools into a splintered and jagged waste, full of the most grotesque forms, which sometimes recall those of the glacier needles.

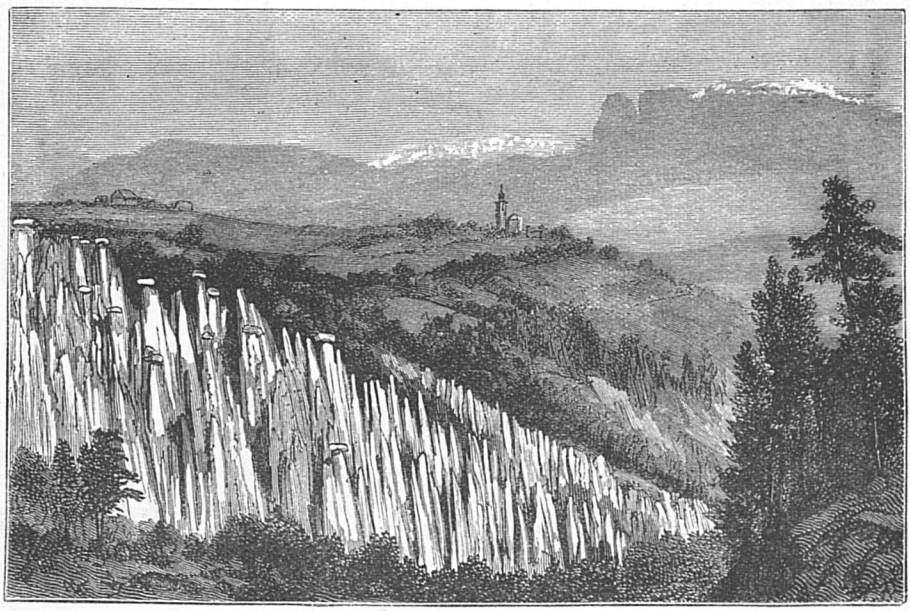
All this is the result of weathering, of the imperceptible but effectual wearing away of the rocks by glacier, snow, and rain-water, by the heat of the sun, which dries up and makes brittle, by the cold which cracks and splits, by the unremitting action of the atmosphere on the body of the rocks. The solubility of the limestone, through which the furrowing of the rocks occurs, must evidently vary; the "Karren" are only found in soluble rocks.

Since no vestige of earth is found on these mouldering rocks, they show no trace of vegetable life, and consequently are devoid also of animal life. They may truly be called the deserts of the Alps.

The largest and most important of the "Karrenfelder" of Switzerland are in the cantons of Appenzell, St. Gallen, Glarus, and Schwyz, but the most celebrated are those on the Karrenalp and Silbernalp, in the Glarner Alps. There are others on the northern slope of the Churfirsten, on the Scherenberg, near the Leistkamm, on the Messmer, on the western side of the Säntis chain, along the Silberplatte, also on the Kerenzerberg, on the mountains of the Wäggi Valley, on the Fluhbrig, the Frohnalp-stock, on the Bauen (Lake of Lucerne), on the Sättelistock, on the Brünig Pass, on the Kaiserstock, on the passes of the Rawyl and Sanetsch, the Tour d'Ay, and the Tour de Mayen. Those in the Austrian limestone Alps are much more extensive, especially on the Salzburg Alps, the Tennengebirge, the Dachstein Group, and the Todtengebirge.

The "Giants' Cauldrons" or eddy-holes, many of which are found in the "Karrenfelder," are, without doubt, the result of erosion. When the loose stones and fragments of rock brought down by torrents or waterfalls are whirled round by the eddy for

some time in the same spot on a ledge of rock, they act as bores on the bottom of the stream, and dig out well-like cavities, which are called erosion-cauldrons or eddy-holes. The name of Giants' Cauldrons was given by the Scandinavians to these cavities, their origin being ascribed in legend to the work of a race of giants. Perfectly round stones, like cannon-balls, are usually found in the cauldrons, which they have hollowed out. At

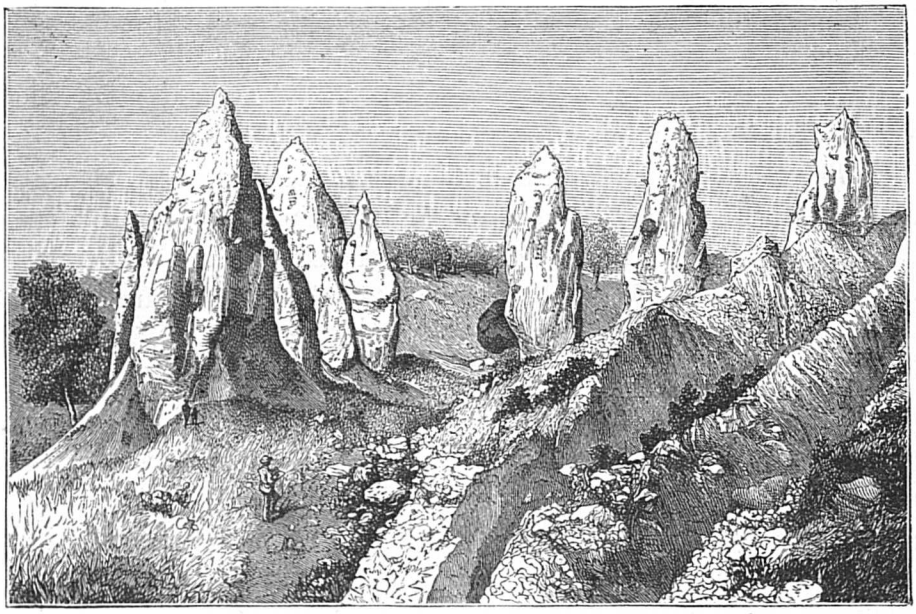


Earth pyramids in the ravine of the Finsterbach, near Botzen.

Gastein, and on the Salzach, at Golling, a large number of cylindrical holes occur, and are known by the names of pot-holes or "Ovens" (Ofen). Circular cavities are also found in great quantity on the Stura at Lanzo, where their formation at the level of the river still continues.

The earth pyramids, or earth pillars, which are formed of loose mountain *débris* by the action of the rain, are the direct opposite to the cauldrons and pot-holes washed out of the hard rock. Large single stones, which have been embedded in the

mass of rubbish, or have lain upon its surface, have acted as a protection for the underlying earth. Thus, gradually, pillar-like or pyramidal forms have risen above the surrounding ground, which has been washed away by rain, each pillar bearing on its summit the protecting cap of stone. By degrees, however, they also have to succumb to the action of the rain-water, and, becoming weaker, the protecting stone falls from them, when they crumble up, and are finally washed away. The appearance of



Rock Needles near Sachas in the Durance Valley.

the pillars of red porphyry *débris*, in the neighbourhood of Botzen in South Tyrol, is very striking. Thousands of earth pyramids, from 30 to 100 feet high, most of them bearing on their summits the stones which have protected them, stand on the slopes of the ravines which have been cut out of the masses of glacial *débris*, by the affluents of the Eisak, the Katzenbach, and the Finsterbach at Klobenstein. They are found singly, at Schönberg in the upper Valley of the Wipp, at Steinegg or

Blumau in the Eisak Valley, on the Jenezienberg at Botzen, on the Fingeller Bach behind the Garner Schloss and Afing, at the Schloss Tirol near Méran, at the entrance of the Passeier Valley, in the gorge of the Revellaunbach at Signat on the Ritten, and at Gödnach-Görtschach in the Puster Valley. Examples of similar pyramids are found also near Lake Iseo, and in parts of Switzerland, notably at Stalden in the Visp Valley, at Useigne in the Val d'Herens, and at Ferden in the Lotschen Valley. They are also to be found in the gorge of the Dard at Aosta, and at Molines on Mont Pelvoux. The rock needles which were found by Whymper at Sachas, near Briançon, in the Valley of the Durance, are of a similar nature, being composed of the material of old moraines.

The formation of caverns in the limestone Alps must also be attributed to the action of water, and principally to the solution of the soft, saline material, the age of the limestone affecting its capability of forming caverns. All limestones are distinguished by being much split up and intersected by clefts. The water constantly penetrates these clefts, and gradually widens them. When a larger channel is formed by the water, the mechanical, wearing action of erosion is added to that of chemical corrosion, and their combined action results in hollowing out caverns in the limestone rocks. The limestone caverns, therefore, stand in close relation to the river and valley systems. The larger caverns have the same kind of irregular ramifications as the valleys, and may be considered as the capillaries of the general valley system, which serve to connect the great arteries. In the formation of caverns, chemical corrosion is greatly assisted when the water contains a large amount of carbonic acid, by increase of pressure, and height of temperature, as well as by the solubility of the rock. An enormous number of caverns are found in the triassic limestone of the northern zone of the Alps, but they are also well known in the southern zone. Certain mountain blocks appear to be completely undermined by

such caverns. The origin of what may be called rift-caverns (Spaltenhöhlen) must be sought in tectonic conditions, and is closely connected with the construction of the mountains, or with seismic disturbance. They are not peculiar to any special kind of rock.

Caverns occur of the most varied form, sometimes appearing as gentle bays in the rock with an overhanging roof, or as low cavities with wide openings, sometimes locally called grottoes, or as closed caverns, or as ravine-like clefts which end in an arch of rocks, or are connected with still deeper clefts and gaps, sometimes extending for two or three miles, and finally as openings through a part of the mountain block from one side to the other. Thus the Frauenmauer Cavern at Eisenerz, in Styria, forms a natural connection nearly four miles long between the Gsöllalpe and the Valley of Tragöss.

The deposits, which partially or entirely fill the caverns, are of great interest. This filling up occurs in two ways, by mechanical transport of the rocky matter, and by the deposition which occurs through chemical action. The deposits usually occur in regular beds, and it would be easy, by comparing the remains of animals found enclosed in them with those of men, which also occur, to determine which were contemporaneous, if more recent causes had not led to their disturbance. The great masses of sediment were deposited in different neighbourhoods by huge bodies of water, at the end of the ice-age, and were afterwards thrown into confusion by the swelling of the cave stream, though they maintained, at least in a few places, the sequence of the strata.

The origin of stalactites is the result of chemical action on the water which percolates through the upper ground; during its slow passage over the roof of the cavern, and its gradual descent, the water loses a considerable amount of its carbonic acid, and a portion of the calcium being set free, forms a pendant. This dropping process gives rise to various formations,

the most simple of which are stalagmite and stalactite in all their varieties. One of the most beautiful stalactite caverns in the Alps is the "Heilige Höhle" (the sacred cavern), in the Valpuszatobel near Fettan in the Grisons, where the similitude of an altar with candles and vases has been naturally formed. The Grotto of St. Maurice in Valais, which was discovered in 1881, and the famous cavern at Balme in the upper Valley of Chamounix, are also fine examples of stalactite caverns, as are also the Stuhleck Cavern in Wechsel, the Sachsenfeld Grotto near Cilli, and the Babji-zob Grotto at Veldes, all in the Austrian Alps.

The formation of ice from the water of the so-called ice-caverns must also be reckoned among the processes by which the gradual filling up of the caverns is effected. Many theories respecting the formation of cave-ice have been propounded, some investigators maintaining that the ice is formed in the summer, as being the season of the most copious evaporation, others that it is the result of the cold of winter, but there is, so far, little agreement on the subject.

The best known ice-cavern in Switzerland is the Schafloch of the Rothhorn on the Lake of Thun. There are several in the Austrian Alps among them being the ice grotto on the Hochkogel in the Tennengebirge, the Kolowrath Cavern in the Untersberg at Salzburg, the Aurach Kahr ice-cavern and the Klemstein Cavern on the Hochlecken Kogel, both at Gmunden, the Teufels-Kapelle (Devil's Chapel) on the Steireck in the Sengsengebirge, the ice-cavern in the Frauenmauer at Eisenerz, the ice-cavern on the Brandenstein at Gams, that at Beilstein in Styria, the Ötscher Ice-Cavern, and the Kalte Loch in the Möll Valley.

The wind-holes or weather-holes are related, as regards temperature, to the ice-caverns. These are deep narrow rifts, which sometimes have an upper opening, but not always. They are found not only in firm rock but also in hills of rubbish and boulder. In fine warm weather, a strong cold

wind comes from them, while in winter they have a higher temperature in consequence of the outer air penetrating them. This arises from the tendency of the air to equalize the temperature. Wind-holes are very numerous in the Alps.

A few remarks must be added, concerning the inhabitants of the caverns. The bones found in cavern deposits, prove, that at the beginning of the ice-age, the animals of the north, inhabited Central Europe. Remains of cave-bears and hyænas are very numerous among the organic breccia of the caverns, but are mixed up with those of herbivorous animals, such as stags, elephants, and rhinoceroses. Most of these animals only sought temporary shelter in the caverns, as bats, beasts of prey, birds and cattle do at the present time. The true cave beasts of to-day, belong to the lower order of animals, principally insects, spiders, &c. The vegetable kingdom is represented in the caverns, only by cryptogams, such as confervæ and fungus. The discovery of human bones in the cave breccia has proved the co-existence of man with the animals of the diluvial age, which adds an anthropological and prehistoric interest to the caverns. In more recent times caverns have been used by man, as places of refuge for criminals, fugitives, and anchorites; many possess historical interest, and round them a whole world of legend clings, with its gnomes and fairies, monsters and hidden treasure.

## CHAPTER XIII.

### THE CLIMATE OF THE ALPS.

THE Alps cover such a large extent of country, and rise to such enormous heights, that they exhibit the most varied conditions, and most striking contrasts of climate. They form a partition between the northern and southern climates to which their two main slopes belong. The northern side sinks gradually into the outlying Bavarian plateau, which being situated 1600 to 2200 feet above the sea, possesses a moderate climate, while the southern foot slopes steeply down to the plain of Lombardy lying nearly 1000 feet lower, and exhibits sub-tropical characteristics. The northern slope is exposed to the arctic winds, from the attacks of which the south is sheltered, while on the other hand the south wind reaches the north after it has been cooled by passing over fields of ice and snow. A similar difference occurs in the valleys within the Alps, with regard to the northern and southern flanks, where the sunny and shady sides form a striking contrast.

The Alpine country on the Provençal coast possesses a perfectly Italian climate, plants beginning to put out their leaves as early as Christmas ; in addition to the olive and the orange-tree, myrtles and laurels, and even palms are found. In the north of Lombardy the climate is so favourable that cypresses and sweet pines, olive and almond-trees, pomegranates and laurel, aloes and cactuses flourish, and the vine, instead of being carefully grown on the ground, hangs in long trails from tree to tree, or high up among the poplars. The climate of Upper Bavaria is quite different, its raw air not permitting the culture of the vine at all.

As the Alps quickly rise to great heights from their southern

foot, which is at only an inconsiderable height above the sea level, and soon reach the zone of perpetual snow, they unite in rapid succession all stages of climate, from that of Italy to that of Lapland. But it is not only the vertical elevation and the slope which influence the varieties of climate; the nature of the ground, the direction of the wind, atmospheric pressure, &c., all have their share in it. Hence it happens that the valleys lying at a considerable height have a milder climate than those that are lower down.

In spite of all these differences, a certain similarity of meteorological conditions may be observed when we compare the mountains with the countries lying immediately around them. The Alps form, as it were, a climatic island, surrounded by four climatic provinces of Europe: the Mediterranean province, to which the coast-lands and peninsulas of the Mediterranean Sea belong; the Northern Ocean province, which includes Western Europe; the Baltic province, to which the western part of the Austro-Hungarian monarchy belongs; and the Pontine province in the east, to which Hungary belongs.

In order to understand thoroughly the climatic conditions of the Alps, the separate climatic factors must be considered. The inconstancy of the weather as regards temperature, wind, and rain, strikes all persons who visit the Alps. These points, therefore, will be the first investigated.

The following table will best demonstrate the varieties of mean temperature of the seasons at fixed points in the Alps. The months included in winter are December, January, February, in spring, March, April, May, and so forth. The table also gives the mean temperature for the year, and the mean highest and lowest temperatures for the year, which facts are well adapted to characterize the warmth of a place, for the latter indicate what is the lowest temperature in winter and the highest in summer that may be expected.

| Group. | Station. | N. Lat. | Height above the sea in feet. | Winter. | Spring. | Summer. | Autumn. | Year. | Mean. Minim. | Mean. Maxim. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Temperature Centigrade. | | | | | | |
| | | ° ′ | | ° | ° | ° | ° | ° | ° | ° |
| I. | Geneva | 46 12 | 1,338 | 1·1 | 9·4 | 18·2 | 10·0 | 9·7 | —11·8 | 32·8 |
| | Bern | 46 57 | 1,882 | —1·1 | 8·2 | 16·8 | 8·3 | 8·1 | —15·6 | 30·8 |
| | Zurich | 47 23 | 1,541 | —0·3 | 8·9 | 17·6 | 8·8 | 8·7 | —13·8 | 30·0 |
| | Munich | 48 9 | 1,738 | —1·8 | 7·5 | 16·6 | 7·8 | 7·5 | —18·5 | 30·4 |
| | Kremsmünster | 48 4 | 1,259 | —2·0 | 7·9 | 17·2 | 8·1 | 7·8 | —16·2 | 30·1 |
| | Vienna | 48 14 | 662 | —0·6 | 9·8 | 19·5 | 10·1 | 9·7 | —15·1 | 33·9 |
| II. | Graz | 47 4 | 1,128 | —1·2 | 9·3 | 19·1 | 9·7 | 9·2 | —15·7 | 31·9 |
| | Laibach | 46 3 | 940 | —1·0 | 9·3 | 19·1 | 9·9 | 9·3 | —17·9 | 31·9 |
| | Görz | 45 56 | 308 | 3·7 | 11·9 | 21·8 | 12·7 | 12·5 | —6·6 | 33·4 |
| | Pola | 45 54 | 275 | 3·8 | 12·2 | 21·8 | 13·4 | 12·8 | —4·4 | 30·5 |
| | Milan | 45 27 | 481 | 2·3 | 13·1 | 23·1 | 13·0 | 12·9 | —9·7 | 34·3 |
| | Turin | 45 3 | 901 | 1·8 | 12·2 | 21·8 | 12·1 | 12·0 | — | — |
| III. | Martigny | 46 6 | 1,633 | 0·5 | 10·7 | 18·7 | 9·9 | 10·3 | —12·2 | 31·8 |
| | Interlaken | 46 41 | 1,872 | —0·1 | 9·2 | 17·3 | 8·8 | 8·8 | —11·4 | 29·4 |
| | Altdorf | 46 53 | 1,489 | 1·1 | 9·5 | 17·3 | 10·0 | 9·5 | —10·9 | 30·2 |
| | Coire | 46 51 | 1,977 | 0·4 | 9·5 | 17·4 | 9·3 | 9·2 | —14·4 | 31·1 |
| | Innsbruck | 47 16 | 1,882 | —2·0 | 8·3 | 17·2 | 8·7 | 8·1 | —16·8 | 30·4 |
| IV. | Ischl | 47 43 | 1,530 | —1·9 | 7·3 | 16·6 | 8·1 | 7·5 | —16·0 | 29·3 |
| | Klagenfurt | 46 37 | 1,444 | —4·5 | 7·9 | 18·1 | 8·1 | 7·4 | —21·8 | 32·8 |
| | Lienz | 46 50 | 2,280 | —3·3 | 8·0 | 17·5 | 7·9 | 7·5 | —17·8 | 29·3 |
| | Botzen | 46 30 | 947 | 1·7 | 12·6 | 22·7 | 12·0 | 12·2 | —8·1 | 33·2 |
| | Luzano | 46 0 | 901 | 2·9 | 11·9 | 20·8 | 12·0 | 11·9 | —7·0 | 33·1 |
| | Aosta | 45 44 | 1,924 | 0·2 | 11·6 | 20·0 | 11·0 | 10·7 | — | — |
| V. | Engelberg | 46 49 | 3,357 | —2·5 | 5·5 | 13·7 | 5·7 | 5·6 | —18·6 | 25·4 |
| | Marienberg | 46 43 | 4,339 | —1·7 | 5·4 | 14·5 | 6·5 | 6·2 | —12·7 | 25·3 |
| | Prägaten | 47 1 | 4,250 | —4·4 | 3·7 | 12·6 | 4·5 | 4·1 | —18·7 | 27·0 |
| | Tamsweg | 47 4 | 3,325 | —6·2 | 4·7 | 14·1 | 4·7 | 4·3 | —27·3 | 28·2 |
| VI. | Grächen | 46 12 | 5,342 | —3·0 | 3·7 | 12·4 | 4·8 | 4·5 | —17·3 | 24·6 |
| | Andermatt | 46 38 | 4,749 | —5·0 | 3·1 | 10·9 | 3·7 | 3·2 | —22·6 | 23·8 |
| | Davos | 46 47 | 5,412 | —5·8 | 1·9 | 10·8 | 3·1 | 2·5 | —24·7 | 25·2 |
| | Bevers | 46 33 | 5,624 | —8·1 | 1·4 | 11·1 | 2·6 | 1·8 | —27·4 | 25·8 |
| | Sulden | 46 32 | 6,044 | —6·1 | 0·5 | 9·4 | 1·9 | 1·4 | —20·5 | 22·5 |
| | Vent | 46 52 | 6,051 | —6·6 | 0·1 | 9·2 | 1·5 | 1·0 | —23·7 | 23·8 |
| VII. | St. Bernard | 45 52 | 8,137 | —7·9 | —2·8 | 6·0 | —0·4 | —1·3 | —22·1 | 17·9 |
| | Theodule Pass | 45 56 | 10,934 | —12·7 | —8·3 | 0·2 | —5·5 | —6·6 | (—21·3) | (15·1)[1] |
| | St. Gothard | 46 33 | 6,865 | —7·0 | —1·9 | 7·0 | 0·4 | —0·4 | —24·0 | 20·0 |
| | Julier | 46 28 | 7,361 | —7·6 | —1·2 | 7·5 | 0·5 | —0·2 | —23·9 | 19·8 |
| | Fleiss | 47 3 | 8,988 | —7·6 | —3·8 | 4·1 | —1·3 | —2·1 | —20·0 | 16·0 |
| VIII. | Rhigi Kulm | 47 3 | 5,861 | —5·4 | 0·7 | 9·1 | 3·2 | 1·9 | —18·9 | 20·6 |
| | Schafberg | 47 46 | 5,824 | —5·6 | 0·0 | 9·4 | 2·9 | 1·7 | —20·0 | 21·7 |
| | Obir | 46 30 | 6,701 | —6·3 | 1·5 | 8·9 | 2·2 | 1·1 | —20·2 | 22·6 |

[1] One year only.

It is evident from this table that the mean temperature of spring and that of autumn approach each other very closely, but the climate of the High Alps, as is shown in Groups VI.—VIII., is much warmer in autumn than in spring.

As a rule, the heat decreases as the height decreases, notwithstanding individual exceptions, but the decrease of heat is less in winter than in summer, the winter of the Upper Alps being comparatively mild, the summer comparatively cold. The extreme degree of cold at a great height, especially on mountain peaks, only slightly exceeds that of the low country on the northern side of the Alps, and indeed is exceeded by that of certain especially cold valleys.

The lowest temperature on the Great St. Bernard during eighteen years was 27·2° C., at Geneva 23·3°, while at Obir, the greatest cold was 27·5°, at Klagenfurt 30·6°. A minimum of 30° was not uncommon at Bevers in the Engadine and at Tamsweg in the Lungau, while such cold had not been observed at any of the stations situated at a height of 10,826 feet.

If the climate of the Upper Alps is compared with that of the polar regions, it will be found that while the mean temperatures of the year are similar, that of the summer and winter are extraordinarily different, as is shown by the two following examples:—

| | | Year. | Winter. | Summer. | Difference. |
|---|---|---|---|---|---|
| Theodule Pass | 10,933 ft. | —6·6° | —12·7° | 0·2° | 12·9° C. |
| Berešov . . | 64° N. Lat. | —4·2° | —21·4° | 14·5° | 35·9° C. |
| St. Bernard . | 8128 ft. | —1·3° | —7·9° | 6·0° | 13·9° C. |
| Jenesseisk . . | 58° N. Lat. | —1·7° | —21·2° | 17·5° | 38·7° C. |

The mean extremes for the year at Jenesseisk are—47·9° and 31·8°. Plants and even trees and field-produce grow in the north, in the height of the summer, at a temperature at which in the Upper Alps the ground is covered with perpetual snow.

Great varieties of temperature occur in the Alps at the same elevation. Generally speaking, the places situated on open slopes, and more especially on mountain peaks, have a compara-

tively mild and cool summer, while enclosed valleys, and particularly those which open to the east, are extremely cold in winter and hot in summer. The coldest winters in the Alps occur in the Lungau, the Carinthian basin, and the Upper Engadine. These valleys are open to the cold east wind, while the warm southern and western breezes are kept off by the mountains. Thus cold air is collected in these basins, and the air which has been cooled on the mountain-slopes by radiation gathers together, and spreading slowly over the valley, forms, as it were, a lake of cold air. It therefore requires a considerable time for warmer currents to displace the heavy, stagnant mass of cold air from these valleys. In calm weather, when there is a high pressure of air, it is not unusual to find warm weather on the mountains for many days or even weeks, while the valleys are still enveloped in severe cold. The mist sometimes lies below, while the peaks are bathed in sunshine, this appearance being always connected with absence of wind, or the prevalence of gentle east or north winds; as soon as a strong south wind blows, the mountains become cold, and the valleys warmer.

It has been shown that, at an increased height above the sea, the autumn is warmer than the spring, while in the valleys there is little difference in these two seasons. The reason for this is that the thick covering of snow which remains from the winter must be melted before the sun can affect the ground of the mountain valleys and Alps. Up to a height of 1600 feet to 2000 feet the difference is very slight, after that it becomes considerable, and is greatest at the peak stations, even though they may not have so great an elevation.

The decrease of warmth with increased height may be explained as follows :—The air receives little heat directly from the rays of the sun, they being almost entirely absorbed by the earth, from which heat is given out to the lower strata of air, and gradually spreads to the higher strata, so that the air is

principally warmed from beneath. Thus the mountain-peaks must have a lower temperature, because the surface warmed is small, and the wind quickly carries away the warm layers of air. When very large masses of mountain rise to a great height, the warmed surface is of greater extent, and there is less dissipation of heat, and consequently the temperature decreases less in proportion as the height increases.

Thus it occurs that the mean temperature of a place depends, not only on the heat supplied by the rays of the sun, but also on the loss of heat by radiation at night and in the winter. The atmosphere allows the rays of the sun to pass through it with scarcely any loss of heat, but not so with the heat that is radiated from the earth. The atmosphere thus forms a kind of screen, preventing free radiation; heat accumulates under this screen, and the mean temperature rises. The thicker the covering, the greater is its effect, and the thinner it is, the weaker is its action.

The higher we rise in the atmosphere, the thinner does it become, and the more freely does radiation proceed. When the sun's rays are not powerful during the day, the warmth which has been absorbed is given back to the air rapidly at night. If the air which has been warmed by the earth rises to the mountains, or is driven up the slopes by the wind, the temperature of mountain and valley is not equalized, because the rising air is quickly cooled down (1° C. for every 330 feet). As the average change of heat in proportion to the height is less than this decrease of temperature, the wind generally cools the peaks instead of warming them, although it brings up the air from the valley.

The pressure of the air in the Alps may be considered very shortly. Like the variations of temperature, the conditions of pressure are very variable and uncertain, but there is this difference, that the altitude of a place has a clearly-defined influence on the condition of the barometer, which follows fixed laws. The mean pressure at every height can therefore be calculated

with sufficient accuracy. The contrary course, however, is frequently taking, and the barometer is used to calculate the altitude of a place. A great many Alpine peaks have been measured only in this way. Protracted observations prove that the mean height of the barometer changes with the seasons, generally rising with an increase of temperature, and sinking with a decrease. If the temperature of the air rises it spreads out, and a portion of the column of air, which was below a certain mountain station, rises above it, and the pressure of air must consequently also rise. The contrary occurs when the temperature of the air sinks. Places situated at a high altitude must therefore have a low pressure of air in winter, and a high pressure in summer, even if no change of pressure occurs at the foot of the mountains.

The influence of the mountains on the hydrometer is very considerable. The amount of watery vapour contained in the atmosphere decreases much more rapidly, relatively to the altitude, than does the pressure of the air. At a height of 6560 feet above the sea, half the body of vapour in the atmosphere lies below, at 13,000 feet about three quarters lies below, while the pressure of air only reaches the half of that on the surface of the earth, at a height of 16,000 to 19,000 feet.

The relative moisture, the degree of saturation of the air with watery vapour, does not change with increase of height according to any fixed law. Usually there is little change with relation to altitude, but there is in the latitude of the Alps a stratum of air saturated with vapour which lies low in the winter, resting sometimes for days and weeks, upon the ground itself, but in the summer at a much greater height. The annual course of the moisture at great heights therefore is exactly the contrary to its course in the valleys—the greatest dryness prevailing in winter, and the greatest moisture in the summer, while in the valleys the air is most saturated with vapour in the winter, and the least so in summer.

Sudden changes and great extremes as regards the conditions of moisture are characteristic of the high mountains. Extreme dryness of the air alternates with bad weather in which the air is saturated with moisture for many days, during which mountains of a certain height are constantly enveloped in clouds. In the valleys and lower parts of the mountains on the contrary, in warm weather it is only occasionally that the air is saturated with watery vapour, and then usually in the night or early morning, when mist is formed.

In connection with conditions of moisture in the climate of the mountains, the amount of evaporation should also be considered. The evaporation in the upper parts of the mountains is much greater, under the same relations of moisture, temperature, and strength of wind, than it is in the lower parts, in consequence of the diminished pressure of air. Everything dries much more quickly at great heights, the dead bodies of animals do not decay, the moisture of the skin evaporates more quickly, the skin becomes dry and liable to crack, and thirst increases.

The accumulation of cloud, shows daily and annual variety. In warmer seasons clouds increase as the heat of the day increases, and decrease in the evening. The behaviour of cloud in the Alps is the opposite to that in the low-lying lands ; in the mountains the sky is clearest in winter, in spring and summer it is most overcast. The peculiar clearness of the winter sky in the valleys of the Upper Alps is the result of the prevailing climatic conditions,which include, besides dryness of the air, and diminished pressure, an intense isolation. These are the peculiarities which, added to the calmness of the air, make certain places, such as Davos, for example, important health-resorts. Isolated mountains projecting towards the plains, on the contrary, have much more cloud than the valleys ; they become quickly covered, and thus often serve to foretell weather.

The mountains have great influence on the condensation of the

atmospheric vapour, and consequently on the frequency and quantity of the rainfall. This arises from the upward movement of the air, by which its rapid cooling, and the consequent condensation of the vapour contained in it, are effected. The ordinary streams of air are forced up the slopes of the mountains, and also local movements of the air upwards are caused by the mountains themselves. Mountains in all parts of the earth thus form isolated regions of frequent and heavy rain. The amount of rain increases as the Alps are approached either from the northern or southern side.

Although the main direction of the Alps does not lie perpendicular to the rain-winds between south-east and north-west, both the outer flanks of the chain have a plentiful rainfall. But as the Alps are composed of several parallel chains between which large longitudinal valleys are situated, the influence of the mountains as rain-partitions causes these valleys to have comparatively little rain, while the outside of the chains has a considerable amount. As a general rule the valleys which open partially towards the plain and have high mountains behind them have the greatest rainfall, while those valleys which are surrounded on every side by high mountains show a decrease of rainfall. Thus the upper valley of the Inn as far as Sis has far less rain than the northern border of the Alps, and the Valais has less rain than the northern side of the Bernese Alps and the southern side of the Valais Alps. Altogether the distribution of the rainfall in the Alps is a complicated phenomenon, which depends in a great measure on the orographical conditions at each point. There is no simple connection between the altitude of a place and the amount of rainfall.

The rainfall varies at different seasons of the year, as the Alps form a boundary between the parts of the continent where the greatest amount of rain falls in summer, to which the whole of Central Europe belongs, and the part in which the maximum fall is in the autumn, including the whole of Southern Italy, as

well as the north of Africa. The relative amount of summer rain decreases towards the south, while the amount of autumn rain increases. Spring and winter do not vary in this respect within the Alps.

The rainfall generally increases with the height among the mountains, but only to a certain altitude above the sea, beyond which it again decreases. The reason of this is probably that the elevation of the land causes increased movement in the currents of air, which are consequently cooled, and on the other hand in calm weather local upward currents pass over the mountains.

The frequency of thunder-storms shows an analogy to the distribution of the rainfall. These storms also are more frequent in the outer belt of mountains than in the valleys of the interior. The storms may be divided, according to their origin, into two classes. One class comes from a distance, and approaches with changes of weather and hurricane, coming especially from the Atlantic. These storms, which extend over a large area, do not occur very frequently in the valleys within the Alps, but expend themselves on the outer flanks of the mountains. The second class of thunder-storm originates in the increased movement of the air, in consequence of its becoming heated on warm summer days when there is no wind. These local storms often remain stationary over the place where they begin, or pass on with the prevailing current of air. They do not disturb the weather of the surrounding country, but simply cool the air by the radial winds which proceed from beneath the storm clouds. It often happens in the Alps that a thunder-storm occurs for several successive days at almost the same hour in the afternoon, and remains stationary, clearing off towards evening, and being followed by a fresh clear night and a bright morning.

Like all mountain valleys, those of the Alps have their peculiar winds. These are either the ordinary currents of air, locally

modified, or special local winds which originate in the place itself. Currents of air are formed, as is well known, when the pressure of the air on the surface of the earth is unequally distributed. The air then flows from the place of higher pressure to the place of lowest pressure. But the moving particles of air are diverted from their direct course by the rotation of the earth towards what is called the centre of depression, that is, as regards the northern hemisphere, to the right. Thus a revolving movement of the air from right to left round the barometric minimum is originated. The particles of air are so strongly diverted from the line of movement, by the rotation of the earth, and the centrifugal force which arises from every rotatory movement, that the direction of their motion becomes almost rectangular towards the lowest pressure. Thus the Alps have southerly winds when the barometric minimum is to be found in the Bay of Biscay, westerly winds when it is to be found over, or north of the North Sea or south of Scandinavia, northerly winds when the minimum is found in the east of the Alps, and easterly winds when the minimum remains south of the Alps, in the Mediterranean Sea. When the minimum comes, as it often does, from the Atlantic Ocean over Scandinavia and Russia, the Alps have first strong south-easterly winds, then southerly, south-westerly, westerly, and finally north-westerly and northerly winds. These ordinary winds, which are created by the unequal pressure of air over Europe, are then variously modified in their course according to the trend of the valleys and the direction of the mountain crest.

Among the changes which the mountains effect in a current caused by the ordinary pressure of air, the most important is the wind known as the "Föhn," which is a southerly wind modified by the mountains. Its name can be easily traced to the *favonius* of the Romans. It is a warm, dry, south-easterly, southerly, or more rarely south-westerly wind, which rushes down with great violence from the Alpine crests. The main seat

of the "Föhn" is between Geneva and Salzburg, and it is immediately dependent on the main chain of the Alps. It occurs most strongly in the Ill Valley in Vorarlberg, in the valleys of the Rhine as far as Lake Constance, the Linth nearly to Zurich, the Reuss, with the Engelberg Aa, nearly to Muri and the Lower Rhone as far as the Lake of Geneva. Its violence is greatest in the valleys themselves; in the upper part of the valleys of the Rhine, the Linth, and the Reuss, as well as in the lower valley of the Rhone, it becomes a hurricane; its strength decreases as the distance from the main chain increases. It occurs only rarely in the Upper Valais, in the Valley of the Aar, between Brienz and Thun, and in the Alpine country east of Salzburg. It is called the warm wind, and also the sirocco, at Innsbruck, and the "Jauk" in Carinthia.

The Föhn, however, in spite of its violence, is welcomed joyfully in the spring, for it melts the snow and ice rapidly, and at once changes the face of the landscape. In the Grindelwald Valley it is not unusual for a snow covering of over two feet in depth to melt entirely in twelve hours. It is a true harbinger of spring, and in twenty-four hours effects more change than the sun does in a fortnight. The places where this wind occurs frequently and with great intensity have a comparatively mild autumn and winter temperature. It blows most rarely in summer, and most frequently in autumn and winter. The Föhn blows on an average from thirty to forty days in the year; it is therefore evident that it must have considerable influence on the mean temperature of the place where it prevails.

The local winds which are peculiar to the Alps are confined to the mountains. The most interesting among them are the day and night winds of the valleys. In all mountainous countries, when no strong ordinary currents of air are stirring, there is found to be a breeze which blows up the valley by day and down the valley by night. These winds are particularly well known on the lakes, on the northern and southern sides of the

range. They have local names which differ with the locality. The wind blowing up the valley is called on Lake Como "La breva," the night wind is called "Tivano." On Lake Maggiore they have the names "Tramontana" (from the north) and the "Inverno" (from the south). On Lake Garda the south wind, called the "Ora," blows during the summer half of the year, from half-past ten in the morning to three o'clock in the afternoon, from the lower end of the lake to the upper, and in the lower valley of the Etsch the "Ora" blows regularly every day up the valley. In the interval between the two opposite winds the air is perfectly still. These winds are well known on the lakes of the Austrian Salzkammergut, under the names of "Unterwind" (the day wind), and "Oberwind" (the night wind). Boats sail to the upper end of the lake with the former, and return with the latter. The inhabitants of the valleys usually consider the regular occurrence of these winds as a sign that fine weather will continue, and not without reason, for their absence indicates great atmospheric disturbance, which rarely passes away from the mountains without storm and rain.

The occurrence of the cool night breeze is easily explained, since it only follows the natural fall of the ground, as the valley floor is cooled down by the air. The air from the cold ravines and gullies sometimes descends like a waterfall. It is not so clear, however, why the air which is warmed in the day-time by the earth does not rise at once, but follows the slight inclination of the valley floor, blowing up it almost as a horizontal wind. It may perhaps be explained as follows. The separate horizontal layers of air, lying against the flank of a mountain, and being obliquely intersected by it, have all the same pressure so long as the temperature is equally distributed, and the air equally balanced, but when the whole mass of air in the valleys and on the flanks of the mountains is warmed by the sun, the air expands, the equilibrium is disturbed, and the air must flow towards the mountain-side. Then the pressure rises, in each

horizontal stratum, in proportion to the distance from the mountain, while on the flank itself it remains constant. The planes of equal pressure are then no longer horizontal, but incline towards the mountain, and at every level the air acquires a downward inclination towards it. The mountain flank being at the same time warmed by the sun, the air along it becomes warmer than that of the free atmosphere at a similar height, and accordingly endeavours to rise. Thus two forces affect the motion of the air on the mountain flanks, one acting horizontally, the other vertically, both causing the air during the day-time to ascend the mountain sides.

Very violent and dangerous storms of wind often arise suddenly on the lakes which are surrounded by high mountains, and have in some places special names, such as the "Mergozzo" on the Lago Maggiore.

While the external configuration of the mountains engenders peculiar local currents of air, the mountains, on the other hand, serve to protect the country lying within them from certain ordinary winds, and cause an exchange of winds between the two slopes. This is seen, to a small extent, in the comparatively slight average motion of the air in the wider valley basins opposite the open plain, it is exhibited in a striking manner in the mountain-chains of sub-tropical latitudes, which, like the Alps, extend east and west; these afford a shelter for their southern slopes from the cold polar currents, and therefore constitute important climatic boundaries. A passage over the Brenner, the Splügen, the St. Gothard or the Simplon from north to south transports us in a few hours from the climate of Central Europe to that of Italy. The climatic transition is much more abrupt there than in the west and east of the Alps; the climate changes, as it were, with a bound. This beneficent action of the great Alpine wall is most strikingly felt in the southern valleys themselves, the plain of Upper Italy being, on the contrary, much colder and more exposed. The Ligurian

coast, the Riviera, is another example of how protection from the cold winds, and exposure to the warm wind, combined with a favourable situation, can result in advantages of climate, which are usually met with only at several degrees farther south.

## CHAPTER XIV.

### THE SNOW REGION, AVALANCHES, AND GLACIERS.

In winter the lower boundary of the snowfall descends to the foot of the Alps, and not only the whole of the mountains, but also the large open valleys, and, on the northern and eastern side at least, the surrounding plains, are covered with snow. In spring and summer this lower snow limit gradually ascends to the high peaks, passing over some that rise to considerable heights. But the highest crests are covered with snow even in summer, a thick layer remaining on them from year to year, which the warmth of the whole summer is not sufficient to melt entirely. This is the region of eternal winter, the snow region, the lower boundary of which is called the snow line or snow limit, that is, the limit of the permanent covering of snow on the mountains.

The expression "perpetual snow," however, must not be misunderstood; the peaks are permanently covered, but not always with the same snow. Wind, avalanches, and glaciers, as well as evaporation, are constantly at work removing the snow from the high mountains. Even on the highest peaks, Mont Blanc and Monte Rosa, warm currents of air and the action of the sun's rays cause the snow to become moist and to thaw slightly.

The two most important factors on which the height of the snow line depends, are the quantity of the snowfall and the mean heat of the sun. According to the most recent observations, the mean temperature for the year of the snow limit in the different mountain ranges of the earth is $-17^\circ$ to $+3^\circ$ C.; within the

Alps the snow line is found to have a mean temperature for the year, in the Swiss Central Alps of −2·8°, in the Hohen Tauern of −3·4°, in the Tyrolean Central Alps of −3·8° C. In addition to the amount of the snowfall and the general conditions of warmth, the exposure of the mountain slopes to the sun's rays and to the warm and dry land-winds must be taken into consideration as locally influencing the position of the snow limit. The fact that the snow line extends farther down, on the northern than on the southern slopes, may be explained by the more intense effect of isolation on the latter. The snow limit also changes with the situation and inclination of the slopes and with the nature and colour of the rocks. This goes to prove that the height of the snow line must be determined for every mountain separately and again for the different slopes. As this kind of observation, however, has been made to a remarkably small extent, it is evident that the snow limits usually given for the greater part of the Alps can be only approximately accurate.

Even on the same mountain the snow line does not always lie at the same height, for the amount of the snowfall varies considerably in the course of years. The difficulty of determining the snow limit has been most successfully overcome by F. Simony, who has ascertained the variations of the snow line in the Dachstein Mountains.

The question becomes still more complicated if certain local conditions of configuration are taken into account. In shady ravines and gullies, or in places where the wind has caused local accumulations, single snowfields and patches are found all through the year far below the proper snow limit, while, on the other hand, they are sometimes entirely absent in elevated spots, where from the height and form of the land they would naturally be looked for. In consequence of these complications, the snow line has been placed at various heights by different writers, ranging from 8300 feet to 10,170 feet.

It is only when the degree of cold is slight that snow falls in

The Ortler and Monte Zebru, with the Schaubach Hut in the foreground.

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large flakes. In the winter it forms fine powdery masses, which have no cohesion, until an increased temperature gradually gives them a little more firmness, or until they are pressed together under fresh layers of snow. The freshly-fallen snow itself is altered under the influence of evaporation and the warm rays of the sun. It gradually forms round nodules which increase in size by thawing and refreezing, and the fine snow passes into the state known as *nevée* or "firn." The fine snow cannot withstand the wind on the exposed peaks and ridges, and is therefore carried away into the clefts and troughs of the high valleys, unless it is protected by a thin covering of snow which has been melted by an increase of temperature. The *nevée*, which is the material from which glacier-ice is formed, has in itself a much stronger power of resistance; hence it is that, generally speaking, scarcely any snow is found in summer on the higher crests and peaks of the upper glacier region, except in this form. This has led one writer, at least, to the erroneous conclusion that the *nevée* limit—that is the mean boundary at which it passes into true glacier-ice—is the actual snow limit, and that a line above which the mountains are covered with snow, summer and winter, does not exist. As some of the glaciers lie far below the snow line, so does the *nevée* line lie at unequal heights with the snow line. It is necessary to distinguish clearly between the snow line, the *nevée* line, and the glacier line.

The density of freshly-fallen snow is very slight; a layer of three feet in depth gives, according to Dollfuss, only $3\frac{1}{2}$ inches of water, but if the same quantity has lain for some time and settled, it gives $13\frac{1}{8}$ inches of water. The great volume of loose snow accounts for the enormous masses in the upper mountains. Although there have been no thoroughly satisfactory researches as to the masses of snow in the upper mountain regions, the supposition that the accumulation of loose snow from autumn to summer reaches fifty to fifty-five feet must be approximately true. Tyndall estimates that since the beginning of the com-

putation of time in the Alps nearly 5600 feet of loose snow have fallen, and the range would have increased that much in height, if abstraction had not kept pace with accumulation. The mountains are relieved from their burden of snow not only by evaporation, thaw and wind, but, as already shown, by avalanches and glaciers.

Avalanches are large masses of snow and ice suddenly put into motion. They originate on the flanks of mountains, where great quantities of snow accumulate, having the earth immediately beneath them, and consequently having no serious hindrance, especially at their outset, to their downward course. Avalanches are formed in various ways, according to the nature of the base on which the snow rests, and have consequently various designations.

They may be divided into summer and winter avalanches. To the latter belong the terrible dust avalanches (Staub-lawinen), which occur very irregularly and are greatly dreaded. They are, in a certain measure, the most aggravated form of snow-storm. A storm of wind raging round a peak where a great mass of fine newly-fallen granular snow is heaped up, first raises it, and then, when the wind suddenly drops, allows it to fall in an impenetrable cloud, or the fresh snow which has fallen on to a very smooth surface of an old frozen "firn," being started by a gust of wind, begins to slide, and increasing in volume, weight and velocity as it goes, is able to pass over any mountain flank. The result which follows is twofold. In the first place, districts, houses, men and women, and cattle, are in a moment completely covered by the descending ocean of snow, in many cases being so deeply buried that only the most immediate aid avails to rescue them; in the second place the compression of the air is so great in consequence of the rapid fall of the snow, that the pressure causes great blocks of rock, houses, stables, objects of all kinds which are not reached by the avalanche, to be overthrown or carried into the air, as by the ex-

plosion of a powder-magazine. The wind being the original cause of these disasters, they are sometimes called wind avalanches. Other agents may, however, serve to set these destructive clouds in motion, for a very slight impetus is necessary to move a body of the fine fresh snow when it is deposited on a smooth, inclined surface.

The ground avalanches (Grund-lawinen), which are more especially peculiar to the spring season, are entirely different both in origin and nature. They are not composed of the fine, dry, granular snow, but of the *nevée* which has lain and accumulated during the winter, and consequently forms a more compact body. It is not to the wind, nor any chance cause that may arise, that they owe the first movement which sends them on their terrible downward course, but to the tepid breezes of the warmer season. These penetrate the small hollow cavities in the great slopes of snow, and dissolve the crystals which lie next the rock or the turf, making the ground slippery, and destroying the intimate connection between it and the snow. Following the law of gravitation, the loosened mass slides down the mountain, towards the valley, gaining speed every second, more or less, according to the inclination of the ground. Every object it meets on its way is involved in the fatal mass and carried downwards with it.

Most ground avalanches have their regular tracks, along which they descend annually in the spring, many of them having special names, such as the Urbachlaui, Bristenlaui, Schwabentobel-lawine. The line of destruction thus being known (generally lying at a right angle to the valley bottom), and the natives of the Alps being learned in the signs of the weather, the form and direction of the clouds, the transparency of the atmosphere, the crumbling away of the edging of snow on the upper ledges of the rocks, the temperature of the air in the mountains, and the warmth of the valleys, it is not difficult for them to calculate the time within which the avalanche will fall, and to take precautions

accordingly. Very often the track of the avalanche crosses a valley which has considerable traffic, making the passage through it extremely dangerous in the spring months.

A spring avalanche of this kind, when seen from the nearest possible point, is an indescribably wonderful sight. Words and pictures are quite inadequate to give an idea of its terror, combining, as it appears to do, the effects of hurricane, earthquake, landslip and thunderstorm, all crowded into a moment. Uproar, flight, destruction, annihilation, accompanied by the crackling of the snow under its own pressure, the deafening crash of splintered trees, the whizzing flight of stones into the air, and their rattling on the mountain sides—in one indefinable, deafening roar, the echo of which is hurled back a hundredfold from every corner of the valley—such is the impression of an avalanche in its immediate neighbourhood. The material is firmer, thicker, heavier than that of the dust avalanches, fixing itself with the tenacity of iron where it falls, and is consequently more fatal to man and beast. Hence it is that in valleys through which a rapid mountain-torrent flows, even in the height of the summer, a bridge of snow is sometimes found remaining from an avalanche, and is often so compact and firm, that horses and carts can be driven over it. This is formed by the stream, which has been obstructed by the avalanche, eating its way by means of its latent heat, through the snow, and gradually widening the arch. If this does not happen, the water which has been stopped by the dam of snow sometimes causes great havoc when the swollen water breaks through the dam, flooding and devastating the lower valley.

The masses of snow which fall in these avalanches are deposited in the form of cones, like those of the mountain *débris*, and are sometimes of extraordinary size, smaller ones containing from 35,000 to 70,000 cubic feet, and larger ones hundreds of thousands of cubic feet.

There is another kind of avalanche, intermediate between these two, and partaking of the nature of both. Flakes of snow being

driven by the wind deposit themselves behind sheltered crests and corners in beds of from thirty to sixty feet in depth, or as self-dependent, projecting shields of snow. They remain firm until they collapse from their own weight, or from the action of warm air, or changed direction of the wind. These "Schnee-Schilder" are the objects to which the mountaineer casts anxious glances, as he wanders among the mountains, especially in the winter, knowing that the slightest occurrence—a sound, a breeze—may loosen them from their narrow base of rock. The postillion does not crack his whip when passing near them, and, before the protecting galleries were built, travellers used to muffle the bells on their horses or cattle as they passed through the narrow defiles of the mountains.

Other kinds which occur much more rarely are the ice avalanches. They are either glacier avalanches, which will be referred to later, or hail avalanches, which occur, but very rarely, on steep slopes after a severe hailstorm.

Avalanches are a common and normal occurrence all over the Alps, as they are in all steep snow-covered mountains, and occur even where glaciers cannot be found. Indeed they belong only to the lower regions of the Alps, especially about the boundary of tree-growth and below it. They scarcely ever occur above an elevation of 10,830 feet. In spite of their devastating fury, avalanches are, on the whole, beneficial to these lower-lying regions, for they clear large tracts of Alpine pasture-lands at one swoop, from an immeasurable load of snow which could not be melted by the warmth of the sun and air until far into the summer. The snow line would lie much lower if it were not for the avalanches, the glaciers would be larger, the climate more severe, and the mountains far less habitable.

The glaciers share with the avalanches the task of relieving the upper mountains from their threatening burden of snow, and thus prevent the complete cooling of the mountains and their surroundings, which must otherwise ensue. But the task is

performed in a very different way, The avalanche brings down enormous masses of snow headlong into the valleys where the increased warmth prepares for them a rapid and certain end; but the glacier, though to outward appearance utterly inactive, carries the surplus of snow from the upper mountains, compressed into firm ice, slowly towards the valley,—sometimes, it is true, proving fatal to man, but otherwise a valuable friend and a promoter of vigorous life.

The scientific study of glaciers naturally originated in their own land, Switzerland, where a large amount of literature on the subject has been issued since the beginning of the last century. Among the earlier writers are Scheuchzer, who wrote a description of his great journey in 1705, Seb. Münster, who explained the difference, not then generally known, between ice and crystals, Altmann, and Grüner. Saussure, whose work, "Voyages dans les Alpes" (4 vols., Neuchatel, 1760 and 1778), caused a revolution in respect to the current views of glaciers, may be considered the founder of a scientific study of the subject. He was followed in more recent times by a large number of able investigators, among whom may be mentioned: Penetz, J. de Charpentier, Agassiz, Desor, the brothers Von Schlagintweit, Dollfuss-Ausset, Hugi, Fröbel, Heer, Mousson, Tyndall, Grad, Forel, Rendu, Torell, Von Sonklar, Simony, Pfaff, Klocke, and Richter. M. Mousson, of Zurich, was the first to provide a manual on the subject of glaciers, which, for the time of its publication, might be called truly exhaustive. The same town can also claim one of the most active and successful investigators of the present day, M. Albert Heim, whose principal work is the "Handbuch der Gletscherkunde," published in Stuttgart in 1885.[1]

[1] How enormous the amount of literature on the subject of glaciers is, at the present time, may be gathered from the fact that, of the thirteen volumes containing M. Dollfuss-Ausset's work, "Matériaux pour l'Étude des Glaciers," three are filled with the enumeration of works on the subject.

The Grindelwald Glacier.

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Every glacier has its district of supply, from which it derives its material. In the Alps these districts are found to be composed of wide trough-shaped valleys, often with upward trending branches, or are cauldron-shaped and surrounded by crests and peaks. The snow slides down from the steep ledges into the broad cauldron, out of which the glacier grows, descending by the only opening, as a huge sluggish stream of ice, towards the valley. The source of supply, which is filled with the coarse-grained snow ("firn," or *nevée*) is called the "Firnmulde," or shortly the "firn," the stream of ice flowing from it is the glacier. The glacier reservoir (Firngebiet) is the part of the glacier which belongs to the snow region, the tongue of the glacier which flows from it being outside the snow region. The boundary between the two is the "firn" line, which, in the summer, indicates where the snow ceases on the glacier. Its height, like that of the snow line is very variable, but it generally lies, according to Hugi, about 660 feet lower than the latter.

The compact transparent glacier ice is composed of the granular "firn" snow, which has been formed in the summer by the superficial thawing and re-freezing of the loose powdery snow of the upper mountains, and collected in the deep troughs. By means of its own weight and the pressure of the masses in its rear, it slowly glides downward, rain falls upon it and it freezes into coherent masses of fine granular "firn," and thus porous ice, the true glacier ice, is formed. But the glacier ice does not then form a single large mass, it is composed rather of numerous blunt-edged pieces, which lie close together, but separated by fine interstices, in consequence of which it is apparently permeable. The glacier ice being full of air-bubbles is of a dull white colour, and more or less opaque; these bubbles, however, are gradually destroyed by pressure, so that the ice at the borders of the glacier is free from them.

Stripes of a dark colour, called dirt-bands, may be seen on the upper, rugged, lumpy surface of the glacier; they are composed

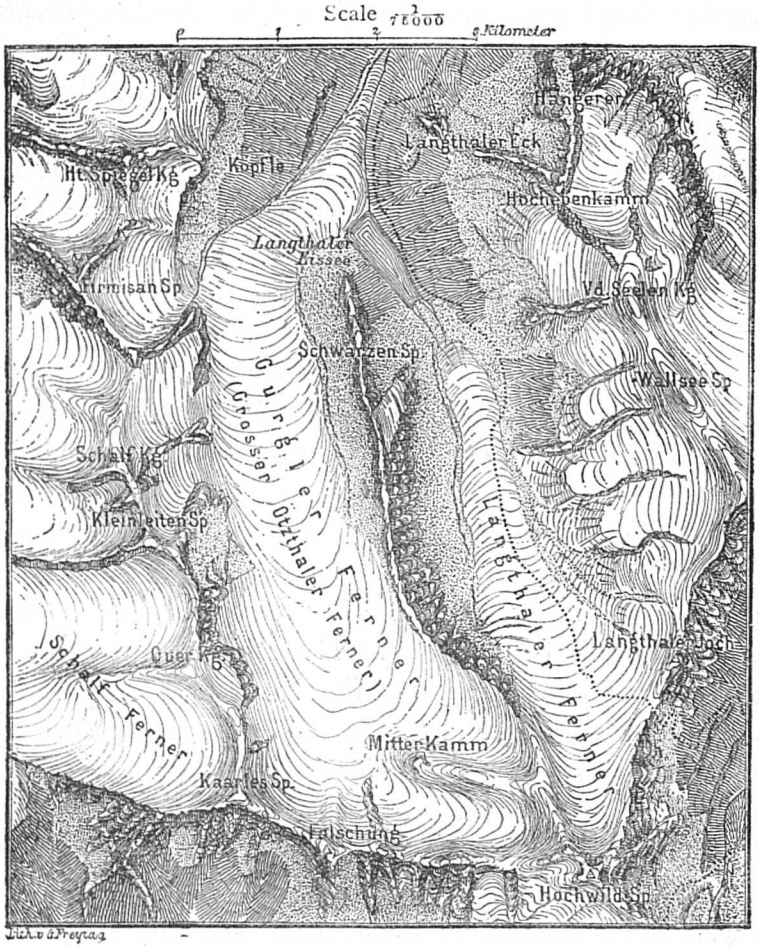
of dust, sand and silt, and are carried along by the movement of the glacier in such a way that they are drawn, at sharp corners, from the edges of the glacier towards its longitudinal axis. The nature of the ice so far changes towards the end of the glacier, that a lamellar construction becomes more evident. Looked at transversely the oblique plane preserves the thick white colour, while seen from the front it appears to be intermixed with transparent stripes of a fine blue. This is the so-called band, or lamellar structure. When the winter snow fills the transverse crevices of the glacier and is pressed down and wedged in before it can melt, milky white bands are formed of varying width, and are embedded in the compact blue ice.

It has been the custom to call the large ice streams which have their origin in extensive troughs of *nevée*, and reach far down into the valleys, glaciers of the first order, and the smaller ones, which lie only on the slopes of the mountain crest, without reaching the valley below, glaciers of the second order.

Glaciers of the first order are found only in the central blocks of the Alps, but glaciers of the second order are found all through the range wherever it rises to the snow region and has plateaux of sufficient size to collect large stores of snow. The most northerly glacier in the Alps is the "Blau-Eis," in the gorge of the Hochkalter at Berchtesgaden; the most north-easterly is on the Dachstein block in the Salzkammergut; the most south-easterly on the "Flitscher Kar" on Monte Canin; the Triglav, which stands next it, has no true glacier.

The following glaciers of the first order are found in the Mont Blanc Group: On the north-western side are the Glaciers du Trient, du Tour, d'Argentière, the Mer de Grace, the Glaciers des Bossons, de Taconnaz, de Bionnasset, de Miage du Borrent, de Tré-la-tête; on the south-western side are the Glaciers de l'Allée Blanche, de Miage, du Brouillard, de Fresney, de la Brenva, de Trebouzie, de Triolet, du Mont Dolent, de Laneuvaz, de Saleinaz, and d'Oruy—twenty in all; to these may be added

from thirty to forty glaciers of the second order. In the Finsteraarhorn Group there are sixteen valley glaciers, and over one hundred flank glaciers; in the Monte Rosa Group there are fifteen primary, and 120 secondary glaciers; in the Ötzthaler Group twenty primary, and 209 secondary glaciers.




The Group of the Gurgler Ferner in the Ötzthaler Alps.

It is estimated that in the whole of the Alps there are 1155 glaciers, of which 249 are of the first order.

The upper ends of the glaciers are always found in the Alps at a height of from 9500 to 10,500 feet above the sea, while the

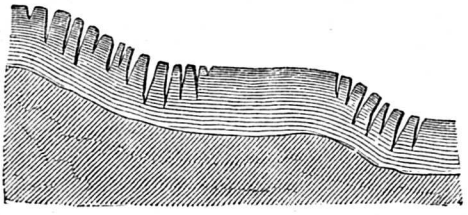
lower ends of glaciers of the first order lie at a height of between 6400 and 4260 feet, those of the glaciers of the second order between 9200 and 7200 feet, consequently far below the snow line. The lowest glacier in the Alps is the Lower Grindelwald Glacier, which in 1818 reached as low as 3230 feet, and in 1870 to 3540 feet above the sea. The Glacier des Bois, in the Mont Blanc Group, reaches as low as 3662 feet, and the Glacier des Bossons 3656 feet above the sea. The Austrian Alps are somewhat weak in glaciers, in consequence of their dry climate; the lowest point reached by the glaciers in this range is that attained by the Mittelburg Ferner in the Pitz Valley, the end of which lies 5700 feet above the sea. These instances will serve to show that the length and volume of the glaciers are very varied. A glacier of the first order is rarely less than three miles long, in many cases they are from seven to ten miles long, and even more; the breadth varies from a few hundred yards to over a mile, the thickness of the ice in the valley glaciers is from 100 to 400 yards and more. The Great Aletsch Glacier in the Finsteraar Group, the longest in the Alps, is fifteen miles long, 5905 feet wide in the middle, and fifty square miles in extent; the contents of its mass of ice has been calculated by Heim to be 14,040,000,000 cubic yards. The next in length are the Unteraar Glacier, over ten miles, the Viescher Glacier and the Gorner Glacier, both over nine miles, and the Mer de Glace, nine miles. The longest Austrian glacier is the Gepatsch Ferner in the Ötzthaler Group, seven miles long, and next the Gurgler Ferner nearly $6\frac{1}{4}$ miles long. The largest area is covered by the Pasterze Glacier (over twelve square miles) on the Gross Glockner. From two-thirds to six-sevenths of the area of the glaciers is situated in the glacier reservoirs.

The collective area of the Alpine glaciers has not been accurately ascertained, but is roughly estimated at 15,000 square miles; in Switzerland alone, it is known to be nearly 810 square miles.

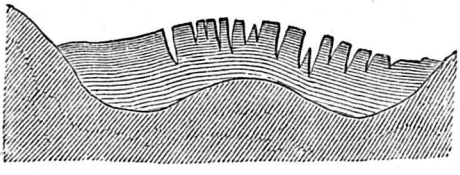
The glaciers extend along the upper valleys of the high mountains, descending towards the lower valleys, like solid rivers, following the bends and windings of the valley. The glacier is apparently motionless, but is in fact always advancing slowly and continuously with measured movement, until its lower end reaches a depth where the warmth of the sun will no longer allow it to remain in a frozen state. During this slow progress, the centre of the stream moves more rapidly than the sides, as is also the case with rivers—the rate of motion increasing progressively from the sides towards the centre. The downward movement is continuous in winter as well as in summer, never proceeding intermittently, it is stronger in warm weather than in cold, and is accelerated by rain and thaw, it proceeds more rapidly over a steep slope than over a more gentle inclination. It has been found by close observation, that a glacier, at its most rapid rate of progress, may advance from 190 to 260 yards in a year. But the line of maximum motion does not coincide with the axis of the glacier, in consequence of the lateral contraction to which the glacier is liable from the unevenness of the contour of the valley. The ridge line of the arched glacier follows the curve of maximum motion, so that the inclination of the surface generally decreases with its width and before a contraction of the valley. When rocks stand in the way the glacier squeezes itself through narrow passes, clings close to the bottom of the valley, suiting its motion to the underlying bed, separates into two or more branches if necessary, unites again, fills up cauldrons to overflowing, rises over obstacles, &c., in a way which causes internal dislocation of its particles, just as occurs in flowing water. The small flank glaciers often take the form of water-drops descending an inclined plane, the whole appearance being that of a slowly-flowing viscous mass.

Although the glacier ice is plastic, it is not ductile, so that when the tension is too great it splits in a direction perpendicular to the tension, and crevasses of various depths

are formed. These crevasses are of three different kinds: (*a*) marginal crevasses, which are never entirely absent, since they are the natural result of the flowing motion; (*b*) transverse or medial crevasses, the occurrence of which is the result of a sudden alteration in the inclination of the glacier bed; and (*c*) longitudinal crevasses, which always appear when a glacier emerges from a narrow pass into an open valley, and never at any other time. Many of the Alpine glaciers are so broken and split up by these deep fissures, that it becomes almost impossible to travel over them, without being led into a labyrinth from which it is most difficult to find a path. The formation of fresh crevasses is accompanied by a noise sometimes resembling singing, sometimes cracking. The length and breadth of the crevasses vary greatly according to the slope and thickness of the glacier; when they first appear they can usually be crossed by a leap, others are more than six to twelve yards wide. Their length has close relation to their width; many are from 200 to 250 yards long. Sometimes a crevasse of this kind reaches from one bank of the glacier to the other, so as to cut it completely into two parts. Most crevasses are narrow towards the bottom; they gradually close up and the ice joins smoothly again. Only very few crevasses are filled with water, for it is usually carried away by underground channels to the stream which first appears at the end of the glacier. The crevasses make the passage over the glaciers very dangerous, for they are often hidden by a light covering of



Glacier Cleavage. Longitudinal Section.

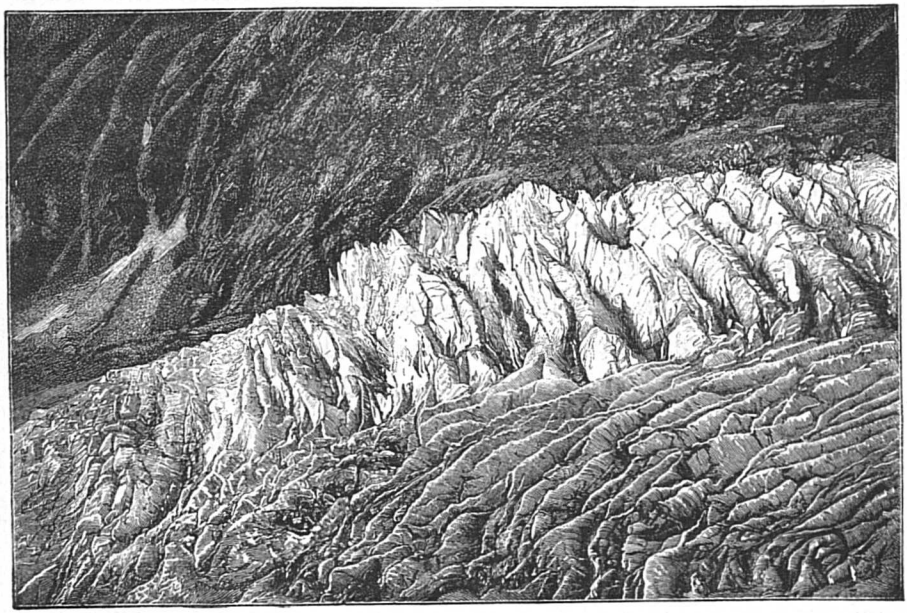


Glacier Cleavage. Transverse Section.

snow, which gives way under the weight of a man. The surface of the glaciers is also covered by thousands of little channels of different sizes, in which clear ice-water flows on summer days; they unite into larger channels, and then fall noisily into deep funnel-shaped holes called "glacier mills" (moulins), and help to feed the glacier stream. The surface of the glacier is most uneven where the rock beneath has a steeper inclination, especially in the upper part where the ice is less brittle; the widest fissures are found there, and at the lower end. At such places the ice which has been pressed forward splits up with great force, irregularly, in all directions, huge blocks are thrown one over another, and under the influence of rain and evaporation soon become moulded into fantastic pyramids, which are called glacier needles, and have the effect of a stormy sea suddenly struck motionless. Such places are the waterfalls of the glacial river, and indeed are known by the name of cascades or ice-falls.

The body of the glacier is constantly diminished by superficial thaw and evaporation, the water, as already mentioned, trickling over the surface, and through the clefts and channels under the ice, in countless veins of various sizes, to the glacier stream. Tunnels, or ice caves and grottoes, are hollowed out partly by the melted ice, and partly by the warm winds. The largest glacier cave forms an arch over the united glacier stream, and constitutes what is called the glacier gate (Gletscher Thor) at the end of the glacier, sometimes having the effect of a fine Gothic arch. The stream of water flows from this, in a strong broad mountain torrent of a thick milky white or light green colour. The thick appearance of the water is caused by fine particles of limestone or granite, which the glacier has worn away from its bed, or from the loose stones brought down by it; the water, however, becomes perfectly clear after a short course, the suspended matter being deposited as glacier mud or "till."

The fact that the lower end of a glacier reaches farther down in one year than in another, has nothing to do with the general receding of the whole glacier, but depends on the conditions of weathering of the particular year. More of it is melted in warm years than in cool years when there is much rain and snow; in the first case, the end of the glacier recedes, in the latter, it advances farther into the valley. Periods may be



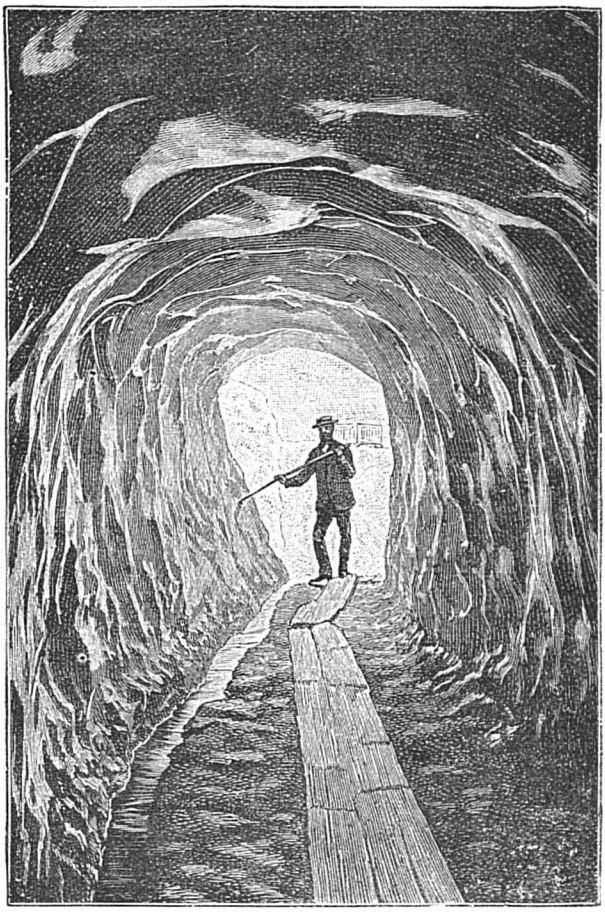
The descent of the Pasterze glacier, on the Gross Glockner.

observed during which all the Alpine glaciers recede simultaneously. The shorter periods include a length of five to thirty years or more. The most recent period of retrogression included the years from 1850 to 1880, in which all the Alpine glaciers receded. Since 1880 an advance of all the glaciers of the Mont Blanc Group, the Pelvoux, and several of the glaciers of the Valais Alps, has been observed, while the Rhone, Aletsch, Glarner, and Unteraar Glaciers, those of the Bernina Group and of the Eastern Alps, are receding.

The advance of the glaciers is not without danger in the lower valley districts, especially when they end in what is called a hanging glacier, over a steep wall of rock. On arriving at the precipitous edge the glacier breaks off in pieces, falling in a glacial avalanche into the valley. Visitors to the Wengern Alp, in front of the Jungfrau, will have seen an example of this. The Sulden Ferner, in the Ortler Group, is also notorious for its ice avalanches. It sometimes happens that the whole valley is obstructed by the masses of ice, and the stream running through it being dammed up soon forms a lake, until eventually the water breaks through the icy dam, when it rushes down to the lower valley with such force that it frequently raises and carries along with it blocks of rock of several hundred cubic yards in extent. The water of the lake forming a wild, muddy torrent, lays waste the whole course through which it flows, tearing up fields, houses, whole villages, and strewing the country round with heaps of *débris*. The Vernagt Glacier, in the Ötz Valley in Tyrol, formed a lake in this way, in 1845, its waters, when they broke through the ice, not only flooding and devastating the wide fertile stretch of valley, but totally destroying the hamlet of Astlen.

The high rocky walls which enclose the glaciers, being acted upon by heat and frost, rain and storm, are subject to a gradual process of destruction; pieces of various sizes break off and fall on to the *nevée* or the glacier, and are carried along with it. These fragments collect on both sides of the glacier, and as they rest undisturbed on one another, their surfaces remain fresh and their edges sharp. The wall of stones thus formed along the side, often reaching a height of twelve to eighteen yards, is called a moraine, or more exactly a lateral moraine. The moraine is not composed entirely of *débris*, this forms only a comparatively thin covering, just thick enough to protect the underlying ice from the heat of the sun, which is constantly lowering the open part of the glacier by thawing it, while the covered portion, being

shielded from its influence, gradually rises higher. Fine matter, such as sand and earth, which is spread over the glacier, either by the wind or the water from the melted ice, on the contrary, assists the melting process, as these small bodies have been



Glacier Grotto on Mont Blanc.

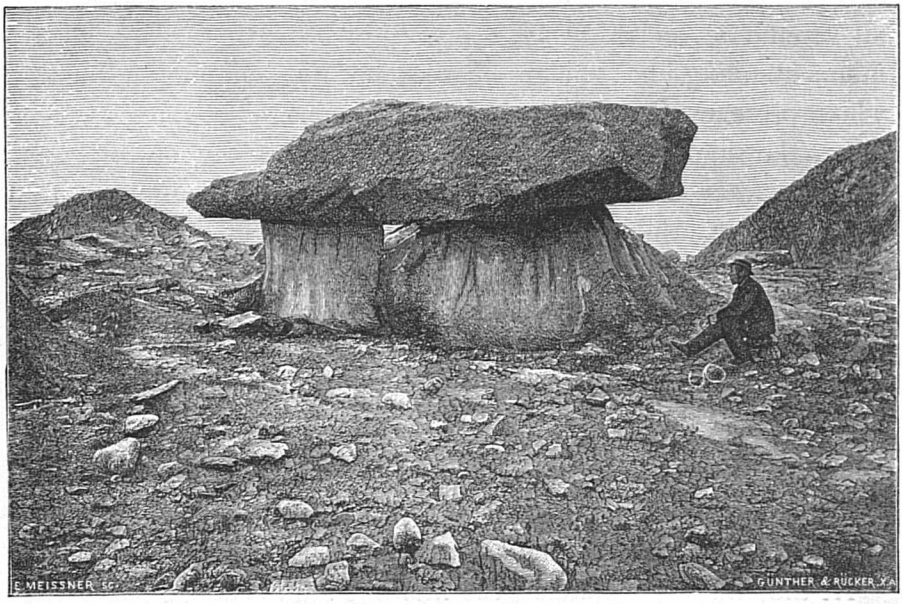
warmed through by the rays of the sun, and therefore melt into the surface of the ice. When two glaciers meet, and then flow along the same bed, two lateral moraines meet in the middle, and thus proceed with the united glaciers; it is then called a medial moraine. Whenever a collateral or secondary glacier

joins a main glacier, another line of moraine is formed. These walls of stone maintain their direction with striking steadfastness, sometimes not even entirely losing it when interrupted by a great ice fall, with its needles and colossal blocks.

Besides the moraine itself, separate blocks are seen on the glacier, which give rise to very striking peculiarities. A great block of rock protects the base on which it rests from the action of the sun, wind and rain, and consequently when the ice all around is melted away, the portion beneath the block remains standing like a pillar, bearing on its summit the stone which protects it, and forming what is known as a glacier table. When the supporting ice becomes so weak that the stone loses its equilibrium, the latter falls, and the melting process round it begins afresh, while the stump of ice which supported it quickly disappears. A great number of these "tables" are annually formed on the Alpine glaciers. In warm seasons, in places where the ice is melted quickly, a "table" may be formed three times in one summer by the same block. Tables are not found on all glaciers, but chiefly on the largest ones: the finest are on the Unteraar Glacier, the Theodule Glacier on the Matterhorn, and the Rhone Glacier in Switzerland; in Austria they are found on the Pasterze Glacier on the Gross Glockner.

At the end of the glacier, the moraine stuff is deposited on the open ground, forming there the terminal moraine, which grows to an enormous heap of *débris*, when the foot of the glacier maintains the same height for a long period. If the glacier advances, it pushes this wall forward and scatters it, casting even the heaviest blocks aside; if the foot of the glacier recedes, part of the chaotic heap on the glacier bottom gradually becomes covered with a mantle of grass. The lowest terminal moraine shows the farthest point to which the glacier has reached, and sometimes lies nearly two miles lower down the valley than the present end of the glacier. A portion of the rocky matter transported by the glacier, having fallen into the crevasses and

having been collected from the sides of the glacier, is enclosed in the interior of it, and forms what is called the bottom, or ground moraine. This is pushed forward, and by the friction to which it is subjected, becomes smaller, rounded and polished, the part worn off being reduced to sand. The glacier bed also becomes smooth and scratched by the stones that are frozen into the bottom of the ice, as are also the rocks which enclose the




Glacier table on the Upper Rhone Glacier.

glacier on either side, especially in places where the bed becomes narrower, and the motion of the ice becomes quicker on account of the increased slope. The pieces of rock which are rubbed and polished by the sliding of the glacier are called *roches moutonnées* or Rundhöcker.

Many theories have been held respecting the movement of glaciers. One of the earliest was that the water which entered the crevasses being frozen, expanded, and pushed the glacier forward; this is called the Dilation theory, and was promulgated in 1723 by Scheuchzer, and afterwards revived by Charpentier

and Agassiz. Another, brought forward by Saussure, was the Gravitation or Slide theory, which asserted that the movement of the glacier was due to the sliding of the ice over the inclined surface of the valley, by reason of its own weight. The observations and experiments of Prof. Forbes on the Mer de Glace on Mont Blanc, first proved that the ice of a glacier flows as a viscous mass. Dr. Tyndall has shown the possibility of this flow, by calling attention to the fact that a continual displacement of the different parts of the ice, by fracture and regelation, is taking place. He showed by experiments that moist surfaces of ice freeze together again very readily under pressure, and Helmholtz has explained the regelation of ice from the physicist's point of view. The fundamental proposition, which is generally accepted, is : That masses which have a granular structure, such as glacier ice, are far more capable of being re-formed than those that have not a granular structure, and that regelation rather increases than diminishes the capability of being re-formed. The density of the ice serves as the moving power, but the glacier granule as the mechanical unit of movement ; it bears the same relation to the glacier, as a molecule of water does to a river.

The transportation of fragments of rock by the glacier, either on its surface or enclosed within it, has been already spoken of. Though the sides of the valley and floor of the glacier are scraped by the stones frozen into the ice, and the bed of the glacier thus gradually deepened, the action of erosion is at present very slight. The question has therefore arisen among geologists whether the glaciers of earlier ages were more active, and especially whether they were able to scoop out the present lake basins of the Alps.

The transportation and erosion by glaciers have another scientific aspect. Accurate knowledge of the action of the glaciers of our day, as it is shown in the scattering of erratic blocks, the deposition of moraine stuff, scratched blocks,

polished and striped surfaces, and *roches moutonnées*, has led to most remarkable conclusions, the results of glacier action having been observed in places where no glaciers now occur. These striking indications are included under the name of glacial formations, and are explained as being the result of larger and more extensive glaciers which came from the mountains and covered the surrounding plain with ice, in the diluvial period of the Ice Age.

On both sides of the Alps, a large number of isolated blocks are found scattered over the mountains; they are of all sizes and are composed of different kinds of rock, many of them differing entirely from any other rocks found in the neighbourhood. These are known as "erratic blocks." The different kinds of rock are arranged in belts or stripes, which spread out in proportion to the distance from the place of their origin. The extensive old moraines which are often found far below the lower end of the present glacier, are composed of such rocks, not belonging to the neighbourhood, and similar blocks are also found at the end of the old glacier paths, and beyond the large border lakes away among the outlying hills and plains. The two belts of moraine on the northern and southern borders of the Alps are composed of terminal moraines lying close to each other, forming irregularly distributed walls of hills, sometimes separated by narrow ravines, sometimes by large depressions in which lie lakes and moors; the country thus formed has a very varied outline. The masses of *débris* deposited in distinct beds, which covers districts where erratic rocks are found, and which may be traced to a height of many hundred feet higher than any existing glacier, is another indication of the much greater extent of glaciers at a former period.

All these indications taken together lead to the conclusion, that the glaciers of the Alps were at one time of very great extent, but they are not sufficient to lead to the acceptation of the theory of an Ice period, though it may be assumed that there

were several glacial epochs within the Diluvial period. The variations in the glacial conditions of the Alps in earlier ages, may perhaps explain the fluctuations of the glaciers of more recent times. To enter upon the various theories by which an explanation of the Glacial period has been attempted, would, however, be quite beyond the scope of the present work.

## CHAPTER XV.

### THE FLORA AND FAUNA OF THE ALPS.

THE Alps, in consequence of their situation in the interior of Europe, of their climatic conditions, and partly also of their geological construction, have a special flora and fauna. It may be remarked, however, that the flora has, generally speaking, a more specific stamp than the fauna.

Possessing as they do every degree of climate, from that of Italy to that of the polar regions, the Alps naturally have an extremely varied vegetation, which offers very striking contrasts. The Provençal coast is adorned with orange-trees, bay-trees and myrtles, and even a few scattered palms, which are green all the year through, and the Italian border of the Alps exhibits pines, pomegranates, bay-trees, aloes and cactuses, while just below the snow line the vegetation dwindles to a meagre scrap of weed and fern. Between these two extremes all the intervening stages are found, so that the Alpine flora is strikingly rich and varied. Geographically the Alps belong to the colder temperate zone, which is characterized by the prevalence of deciduous trees, and in Europe extends from 45° to 58° N. latitude ; only the southern portion of the Western Alps extends beyond the 45th parallel, so that this part of the country may be included in the warmer temperate zone, with its evergreen foliage. The favoured valleys on the south of the Alps, which open into the Lombardo-Venetian plain, with their Italian climate, form an exception, as they lie north of the 45th parallel.

With regard to their vegetation the Alps may be divided into two main regions, the Forest region, and the Alp region, which may be again separated into three subdivisions, the limits of which have been given as follows :—

| | | N. Alps. | | Cent. Alps. | | S. Alps. | | Mean. |
|---|---|---|---|---|---|---|---|---|
| | | West. | East. | West. | East. | West. | East. | |
| | | Feet. | Feet. | Feet. | Feet. | Feet. | Feet. | Feet. |
| VI. Upper } | to | 8530 | 8102 | 9594 | 9234 | 9381 | 8530 | 8843 |
| V. Middle } Alp Region. | „ | 7217 | 6561 | 8315 | 7217 | 8315 | 7217 | 7482 |
| IV. Lower } | „ | 6890 | 6460 | 7986 | 6890 | 7986 | 6890 | 7118 |
| III. Upper } | „ | 5854 | 5328 | 6890 | 5854 | 6806 | 5854 | 6097 |
| II. Middle } Forest Region. | | 4690 | 4590 | 5328 | 4264 | 5248 | 5328 | 4909 |
| I. Lower } | „ | 2623 | 2295 | 2770 | 3197 | 3722 | 3197 | 2968 |

On beginning the ascent of the lower forest region, we are surrounded by woods of oak and Scotch fir, by swamps with sedges and reeds and long rushes, by waving cornfields, and, where the situation is favourable, by chestnut woods and vine trellises. The chestnut, with its imposing size, its wealth of foliage and noble appearance, forms one of the chief ornaments of the southern Alpine valleys. After a short ascent the second region is reached—the region of the long-stemmed pines, larches and fir-trees, and of beeches, alders and willows, at the feet of which coarse grass and sedges form a thick matted carpet—while agriculture and fruit-culture give place to pasture-land. In very favourable spots, however, corn is grown much higher up. It is cultivated not only on the ridge of the Brenner (4800 ft.) on the St. Gothard, and on the Grisons Alps, but also on Monte Rosa itself, at a height of 6496 feet above the sea. In the upper forest region the forest-trees become more scarce, while the needle-leafed trees are recruited by the stone-pines, which are found together with the Alpine rose-bushes, and coarse grass flourishes in their shadow. In this region we find the boundary woods (Bannwälde) which are held sacred and inviolable by the inhabitants of the mountains. These woods by

means of their strong tree-stems are able to prevent the great masses of snow from breaking away and slipping down in the winter, though not, as is generally believed, of stopping an avalanche that has once started downwards. They consist chiefly of stone-pines and larches, but also of pitch-pines and firs, with here and there a maple or a birch, the only deciduous trees of the Alpine upper woods.

Human habitations become rare in the upper forest region, and the few dwellings that are found are chiefly refuges for the farmers of the district, and for huntsmen and tourists. With these we reach the upper boundary of the woods, the trees no longer appear in close patches, but are scattered around, and exhibit in their distorted forms and decayed branches, the result of exposure to the free and unobstructed winds.

The forest region generally extends much higher on the crystalline rocks of the Central Alps, than on the limestone Alps, but there are numerous local exceptions. The conditions of exposure of the slopes give rise to great variation in the level of the boundary-lines, and trees are consequently met with in isolated places far above the middle forest boundary, as, for example, in the neighbourhood of the Wormser Joch. Larches are found at a height of 7620 feet, stone-pines at 7760 feet. The largest circuit within which important deviations from the level of the tree limit are found is in the French Alps, where they are the result of warmer climate, and the change of aspect; in this part of the range, larches and stone-pines are found at 8200 feet above the sea, a height to which they attain in no other district of the Alps, whereas the firs in the steep rock of the Grande Chartreuse, which reach 6165 feet, remain below the level which is ordinarily reached on the Central chain.

From the forest region we enter the Alp region, the lowest stage of which extends to the upper border of the knee-wood. This dwarfed form of tree is represented in the Alps by foliage-

trees and by needle-leaved trees, the former being found on the schist mountains, the latter on the limestone and granite. The Alpine alder, which grows to a height of from three to ten feet high, and resembles the birch in its habitat, grows on the schist mountains to a height of nearly 7550 feet, but reaches far down towards the valley on the banks of the torrents and in the avalanche tracks. The tree which is peculiar to the limestone and granite mountains is much more striking, on account of its original and fantastic forms. This is the dwarf pine or "Legföhre," which has many different local names throughout the Alps. It is often seen at a height of 3740 feet, but extends as high as 7550 feet above the sea. Its appearance is very striking and picturesque. Its reddish-brown stem creeps along the ground for a distance of from ten to thirty feet, its end rising in a pyramid of from six to sixteen feet high. Its branches stretching along from near the root, bear long, thick bunches of dark-green needles, and bright, yellowish-brown, egg-shaped cones, which turn upwards or sidewards. Wherever there is a thin layer of earth on the granite, wherever the roots can find the slightest nourishment in the rifts of the rock, this odd creeping tree flourishes, beneficently clothing the bare slopes with its soft green branches. It often grows over high and precipitous walls of rock, hanging like a decorative garland over gloomy chasms. In some very shady places it grows far down in the valleys, as, for example, on the western shore of the Hallstätter Lake (1770 ft. to 1640 ft.) and in the upper valley of the Erlaf. The upper limit of tree growth is immediately succeeded by the region of the Alpine plants which prevail in the middle and upper Alp region; this extends to the lower limit of perpetual snow. The flora of this zone greatly resembles the polar flora, trees having entirely disappeared with the exception of a few scanty bushes in the deep valleys. The plants become smaller and fewer as the height increases. The weeds and grasses grow close to the ground. They throw out long fibrous

roots, but have short stems, the leaves which are firm and hard, spread themselves flat against the earth, while their bright-coloured blossoms, on the contrary, are often of a great size and far exceed those of the plains in beauty. The queen of the Alpine plants is the Alpine-rose. It is sometimes found in single plants, sometimes clothing whole mountains, with its tender green leaves and bright carmine blossoms; beginning in the forest region as low as 4260 feet above the sea, it extends upwards to a height of 7550 feet. The many-coloured gentians and the edelweiss may be classed with the Alpine-rose as being specially characteristic. Besides those plants already mentioned, the high pastures, the banks of the streams, and mounds of *débris* are adorned with a varied array of bluebells and primulas, azaleas, heaths, asters, anemones, speedwells, wild thyme, orchids, and artemisia, violets, the dwarf forget-me-not, and many others, all surpassing their sisters in the depths of the valleys, in size and in brilliancy of hue.

The high mountain pastures, which are sometimes of considerable extent, horizontally as well as vertically, on account of the contour of the mountains, are very important to the inhabitants, since they enable cattle-rearing to be carried on, on a much larger scale than there is room for in the valleys.

A great part of the Alpine summits is covered with this vegetation, but numerous peaks ascend high into the snow region. The latter, as has been shown, forms an unbroken district, sometimes descending lower, sometimes ascending higher, so that in favourable situations the Alpine vegetation may extend upwards to a height of 10,170 or even 11,150 feet above the sea. The flora of this region, which in the Eastern Alps alone covers a total area of over 770 square miles, is, naturally, very sparse, consisting generally of *algæ*, lichens, and mosses, while a few separate species of phanerogams, such as the *Silene acaulis* and the *Saxifraga oppositifolia*, grow in the small tracts of this district which are occasionally free from snow.

Finally, a trace of organic life is found even on the glacier fields. Large surfaces of old snow, or *nevée*, often measuring some hundreds of square yards, sometimes appear to be covered with a flush of red colour, varying from pale pink at the edges, to a bright carmine in the middle. The colour of this red snow is due to microscopic little snow *algæ* (*Sphærella nivalis* formerly *Protococcus nivalis*), simple vegetable cells with red contents less than $\frac{1}{1000}$ of an inch in diameter, which vegetate in countless numbers in the spaces between the granules of snow.

We will now turn from the vegetable kingdom, to the animal kingdom of the Alps. The fauna of the Alps, with regard to its descent and its original home, is composed of three elements. One portion may be considered as the altered remnant of an earlier tropical and sub-tropical race, which inhabited Europe in the Eocene and Neocene periods, and whose nearest relatives are now to be found partly in tropical Asia, partly in sub-tropical America, and in the islands of the Atlantic; such are the kingfisher, the jay, the woodpecker, and the quail. Another portion consists of species which have wandered here from the north, and taken refuge in the mountains, such as the marmot, and the ptarmigan. A third portion, which is constantly being recruited by stragglers even at the present day, consists of the wanderers from Northern and Central Asia, such as the leming, and the fieldfare.

Animal life appears in the Alps at heights corresponding to those at which vegetable life is found, the lowest form of animal life, the *infusoria*, appearing together with the red snow *algæ* on the ice of the glaciers; next come *acari* and some spiders.

The number of animals and the number of species generally increase with the decrease of height above the sea, so that the lowest Alpine region is the richest in this respect.

The animals are distributed as follows:—

I. Mountain region (2620—4260 ft.).

(*a*) Mammals. As regards number, the mammals are far exceeded by the birds. The species of wild mammals of the mountain region, which are constantly decreasing in number, is confined to several kinds of bat, the hedgehog, the shrew-mouse, the mole, the otter, the polecat, the rock-marten and pine-marten, the ermine, the weasel, species of mice and hares.

(*b*) Mountain birds. The woods, the clearings, the streams and lakes are inhabited by a vast number of birds of various kinds. The least numerous are the waterfowls, the wild duck, water-hen, and heron, in consequence of the larger Alpine lakes lying far below the mountain region. The forest birds, on the contrary, are especially plentiful, both as regards species, and individuals. Snipe, ptarmigan, the mountain-cock, the heath-hen and pigeon are dear to the sportsman. The most remarkable of the climbers are the cuckoo, the lap-wing, the kingfisher, and the many-coloured jay. A great variety of smaller birds, most of them songsters, are found here, such as the fly-catcher, the crossbill, the brambling, the green-finch, the linnet, the goldfinch, the yellow-hammer, the lark, various pipers, the titmouse, the little wren, and the smallest of European birds, the golden-crested wren; besides these there are hedge-sparrows, robins, redstarts, shrikes, water-wagtails, blackbirds, thrushes, and starlings. To these may also be added, the jackdaw, the raven, the crow, and the chough. The owl family is represented by the great and little horned owl, the dwarf-eared owl, and some varieties of screech-owl. In addition to these nocturnal birds of prey, there is a vast number of those which hunt by day, such as the goshawk, the sparrow-hawk, several varieties of the falcon, the buzzard, the eagle, and the vulture.

(*c*) The lower animals. The Alpine lakes and streams, even the wild mountain torrents, are full of fish, the most important being the bass, and the trout; pike, salmon, perch, and grayling

are also found in considerable numbers. Little need be said respecting the frogs, toads, lizards, and salamanders of the Alps; the only poisonous snake of this country is the *Vipera aspis*. The number of molluscs, spiders, and insects, is enormous.

II. The Alp region (4260—7550 ft.).

(*a*) Mammals. A good many of the animals mentioned above extend also into the Alp region, some as far as the tree limit, some beyond it, such as the bat, the mole, the hedgehog, the badger, some species of marten, and the fox. The number of mammals peculiar to this region is smaller; they include some varieties of mice, the Alpine hare, which becomes white in winter, the marmot, and the chamois. Of the larger beasts of prey, the lynx, the wild cat, the wolf, and the bear, are still found, though their number is constantly decreasing.

(*b*) The birds of the Alp region are represented by the large birds of prey (the rock eagle, the golden eagle, and the golden vulture), some kinds of crow, wild hens, and a few smaller birds of the lark, swallow, and stonechat kind, while the nocturnal birds of prey, marsh and waterfowl, and a large number of smaller kinds, disappear.

(*c*) The lower animals. These also are much more sparely represented in this region. Typical kinds of lizard are the mountain lizard, and the pretty mountain salamander. The most numerous kind of insects are flies and butterflies. Molluscs and worms are reduced to a few kinds.

III. The snow region (7550 ft. to 14,930 ft.).

(*a*) Mammals are so rarely found in this district and are so concealed, as to have apparently entirely disappeared. The snow-mouse alone perhaps spends his whole life in the snow region, the higher kinds of animals only appearing occasionally, as the marmot, and the wild goat so eagerly tracked by the huntsman, but which is now only found in the chain of Alps between Valais and Piedmont.

(*b*) Birds. Birds appear in somewhat richer variety, although there is no kind especially peculiar to the snow region. The true representatives of bird-life in these heights are the crow, the mountain-jackdaw, the ptarmigan, and the brambling.

(*c*) The lower animals. All forms of animal life disappear before the endless winter and the dearth of food. Only two kinds of reptile may be noted as inhabitants of the Alpine belt of snow, the mountain lizard, and the common viper, with its black variety. The insects are confined to several kinds of flying beetles, about a dozen butterflies, humble-bees, and wasps. The cosmopolitan earth-worm is apparently the only member of his family which ascends as high as the upper snow region; a variety of centipede, and also snow mites, and two or three varieties of spider—as well as the *infusoria* already mentioned—all manage in some wonderful way to support life at these enormous heights. The dark glacier flea (*Podura glacialis*) also colours the ice of the glaciers on wide patches. The last specimen of animal life is the carpenter-spider or daddy-long-legs, which has been found on the Piz Linard in the Silvretta Alps, at a height of 11,210 feet above the sea.

In conclusion, a few words must be devoted to the domestic animals of the Alps. Of the larger mammals which have for centuries been eagerly pursued, either on account of their destructiveness or for profit, very few exist in a free state, in the Alps, or indeed in any part of Europe. Their place is beneficently filled by a large number of faithful domestic animals. These have also some special peculiarities in the Alps, by which they differ from the races of other districts. The superiority of the Swiss cattle is recognized even out of Switzerland. But the cattle of the Austrian Alps, especially that of Tyrol, Salzburg, and Styria, is also excellent, being indeed the best in the whole monarchy. The numerous goats, whose relationship to the wild goat and the chamois are here very striking, live a free and happy life on the mountain pastures. Sheep are

scattered about everywhere, pasturing even in the most dangerous spots, the Bergamasker sheep being the most peculiar among them; the latter are driven in large herds, up to the mountain pastures among the Italian Alps for the whole summer. Pack-horses and mules carry heavy burdens over the tedious Alpine roads, though their employment is constantly decreasing since the construction of the Alpine railways, as is also the number of those big-boned mountain horses, who carry letters and parcels over the great Alpine passes. On the southern side of the Alps the ass takes the place of the horse in a great measure. This district also possesses one or two interesting breeds of dogs, the short-haired sheepdog of the Bergamasker shepherds, among others, being worthy of mention. The famous St. Bernard dogs, which are unfortunately extinct, apparently originated by crossing the breeds of the Danish mastiff and the Valais sheep dog; they were for a long time in the service of the noble monks of the Hospice of the Great St. Bernard and rescued many hundred persons from perishing in snowdrifts and avalanches. Leonberg and Newfoundland dogs now take their place. Dogs are also kept on the St. Gothard, the Simplon, Splügen, Grimsel, and Furka, which have an extremely keen scent, and do splendid service.

## CHAPTER XVI.

### MAN IN THE ALPS.

THE population of the Alps belongs to the three principal European nations, the German, the Romanche, and the Sclav; and as the Romanche is again divided into French and Italian, there are four leading nationalities, each of which has numerous subdivisions, with an incredible number of dialects. The remains of the pile-dwellings found in the Swiss lakes in the dry summers of 1853 and 1854, and afterwards in the lakes of Upper Italy, Bavaria, and Austria, give important information respecting the earliest inhabitants. It is supposed that their builders must have been of Celtic or perhaps Finnish origin. In very early times the Rhætians dwelt on the southern side of the mountains in the district of the Padus (Po), extending far into Italy, and were perhaps of kindred stock with the Etruscans. Being invaded by the Celts from the north-west, especially on the Rhone, and in a great measure dislodged from their possessions, they retired from the fertile plains of the Po to the inhospitable mountain lands, and settled in the district between St. Gothard and the Gross Glockner, extending as far as Lake Constance and the source of the Lech on the north. The Celts in the meantime occupied the southern valleys of the Alps and the whole of Upper Italy. But as the dominion of Rome constantly spread farther over the Italian peninsula, the Celts of the Po Valley were overthrown in their turn; the Romans crossed the Alps, and incorporated the district of the Gauls—who dwelt on the further side of the main crest, including the Helvetii in what is now Switzerland, and the eastern mountain country—with the

Roman Empire, under the names of the Rhætian, Norican, and Pannonian provinces. This occurred shortly before and after the birth of Christ. The Romans then fortified strong stations for their legions on the rivers, which quickly developed into towns, carried military roads over the mountains, and introduced Roman culture into the Alpine country. The Germans, however, from the north, penetrating as far as the Danube, set a limit to the Roman lust of conquest, and, as the empire became weakened by increasing anarchy, crossed the Danube, in 476 B.C., destroyed the western empire of the Romans, and thus became masters of the Alps. In the terrible time of the migration of the nations that followed, there was a constant coming and going of the most varied races, till finally permanent conditions were restored. After the migration, the southern slope of the Alps were held by the Germanic Langobardians, who soon, however, became Romanized, the western slope by the Burgundians, who were also afterwards Romanized, and the greater part of the Upper Rhine district by the Alemanni or Suabians. A remnant of Rhæti, who had become half Roman and mixed with the Germans, settled in what is now known as the Grisons and the Vintschgau. In the Tyrolese mountains and on the high plateau extending to the Danube, between the Lech and the Enns, several remnants of mixed Germans settled, and united into one people—the Bavarians.

The Alemanni remain to the present day pure German, or else —like the German Tyroleans—have assimilated the foreign elements of the Rhæto-Roman and Sclav nationalities. On the eastern slopes of the Alps, especially on the Drave and the Save, the Sclavonian tribes—the Wends—had made irruptions, but were overpowered by the Germans, so that even in the east the district occupied by Sclav races is very limited. The names of places show plainly how much of the Alps were once possessed by Rhæto-Romans and Wends. The most powerful of the German races, which had its share of the Roman Empire, was that of the

Franks. They conquered Roman Gaul, made the country of the Burgundians and the Lombards dependent, and subdued all the people of Germany, so completely, that their King Charlemagne, about the year 800, ruled also over the whole Alpine country as Roman emperor. From the time when the great empire fell to pieces under his successors, in 843, the Eastern Alps and the eastern part of the Central Alps belonged to the German Empire, whose sway extended also over Italy. Burgundy remained an independent kingdom until 1034, when it was joined to Germany by Conrad II. Ultimately the Roman portion of Burgundy was separated from that occupied by the Alemanni; the latter, including the country lying on the Rhine, the Saone, and the Isère, fell to the share of France, while the former, consisting of the greater part of Switzerland, remained part of the German Empire up to the end of the middle ages. The foundation of the Swiss Confederation was laid in the beginning of the fourteenth century, but it was not formally recognized as a state community till the Peace of Westphalia, in 1648. The eastern part of the Alps remained a possession of the German Empire as long as the latter endured, that is till 1806. The various smaller states were united into a compact system by Austria; the extreme north was, and continued to be, Bavarian. The Italian Alps were for centuries divided among the trade Republics of Genoa and Venice, and the German Empire, while Milan was independent. The territorial boundaries within the Alps were defined by the Vienna Congress, of 1815, which met after the revolutionary period of the Napoleonic despotism. The new Austrian Empire, in addition to the Alpine country which it had previously possessed, received the Archbishopric of Salzburg and the Lombardo-Venetian kingdom, the north of which touches the Alps. Lombardy, however, was lost, by fortune of war, in 1859, and Venetia in 1866, both falling to the share of the newly-created kingdom of Italy; the latter ceded Nice and Savoy, in the Western Alps, to France, in return for the help which that country had given to Italy.

The following states, therefore, have a share in the Alps: (1) France, with Nice, Provence, Dauphiné, and Savoy, and the little principality of Monaco in the Riviera; (2) Switzerland, with the cantons of Geneva, Valais, Freiburg, Berne, Unterwalden, Uri, Schwyz, Glarus, Zürich, Zug, Lucerne, Thurgau, St. Gallen, Tessin, and Grisons; (3) the kingdom of Italy, with Genoa, Piedmont, Lombardy, and Venetia; (4) the little principality of Lichtenstein; (5) Bavaria, with Suabia and Upper Bavaria; and (6) the Austro-Hungarian monarchy, with Tyrol and Vorarlberg, Salzburg, Upper and Lower Austria, and on the south of the Danube, Carinthia, Styria, northern Carniola, Görz and Gradisca, and in the furthest outlying spurs, with Hungary, Croatia and Slavonia.

Reckoning the entire population of the Alps at from seven to eight millions, the proportion of the different nationalities is about 3 to 3½ millions each of German and Romanche, and about one million Sclav inhabitants.

If we look a little closer into the distribution of the nationalities, we shall find that the Germans inhabit the whole of the northern portion of the range, not only the northern outliers, but also a considerable part of the primitive Alps, and, in fact, extend over the southern slope of the latter. The German lingual boundary passes southward over the watershed in the Lys Valley, where it reaches its most southerly point at Issime, and in the district watered by the affluents of the Sesia, then is found in the Valley of the Tosa, in the Pommat, and in Gurin on the Meggia, the only German village in Tessin, then in the Etsch district and at Bladen in the district of the Piave, and Tischelwang in the district of the Tagliamento. The Italian language extends over the watershed in the Val de Lei, east of the Splügen, into the Rhine district, and at Livigno in the district of the Spöl, a tributary of the Inn, into the district of the Danube. The German boundary, on the other hand, remains at a considerable distance from the watershed in the district of the Upper Rhine, in the Engadine, and in the Gördner and the Gode Valleys,

where the Rhæto-Roman race have continued to dwell, between the Germans and the mountain-crest. Some isolated districts occur in which the language differs from that of the surrounding country, such as the colonies in the Grisons of descendants of the Alemanni, whom the Frankish emperor settled there to guard the Alpine passes, and that in Rimella, to the south of Monte Rosa, where the colonists who came from Upper Valais have maintained the German nationality, quite independently of their surroundings, ever since the thirteenth century. Lingual islands of this kind are found also in South Tyrol, in the Nonsberg, Fliemser and Fersina Valleys, where the population is completely Italian, and the two well-known settlements of the "Sette" and "tredici communi" in the Italian Alps. French prevails in the western part of the Alps, in Geneva, Lausanne, Savoy, and the valley of the Rhone, where various dialects are also used. The most peculiar *patois* is that of the Provençals between the Var, the Rhone, and the Durance. The French element is constantly spreading from Lower Valais into the German district of Upper Valais; on the boundary-lands of the two parts, French and German inhabitants are mixed. The people of Italian nationality dwell in the parts east of the French and south of the Germans, where they use the Piedmontese, Milanese, Bergamask, Trientine, and Friulian dialects. The Friulian dialect is the farthest removed from true Italian, the Friulians being Romanized Carinthians. The Waldenses dwell east of Monte Viso. In South Tyrol, Italian preponderates greatly over German. The Rhæto-Romans or Ladiners, who have been erroneously reckoned among the Italians, are Romanized Rhætians, who dwell in the Engadine, and the Münster Valley in Switzerland, and in the Grödner Valley, the Abtei Valley, and Enneberg in Tyrol. The south-eastern part of the Alps is inhabited by the Sclavs, belonging to the southern Sclavs, and are partly Wends—usually called Slovoniens in the south-eastern districts of Carinthia and southern Styria, in Carniola and in the

coast-lands—and partly Croats, who dwell east of the Wends. The Chorwaten hold a small strip of country east of Graz, between Germans and Magyars. Some Magyars are found dwelling in the eastern spurs of the Alps on Hungarian ground, but there are as few of the characteristics of the Alps found among them, as there are traces of the Alpine configuration in their mountains.

Such are the different races by which the country of the Alps is peopled. A few words should now be devoted to their character, occupations, costume, and dwelling-places.

The mountains, with all their peculiar conditions, naturally influence the inhabitants, and give a very definite stamp to their character. The mountaineer gains his bread in the midst of danger, and with great exertion, often seeing the labour of a whole year destroyed by a single storm. Shut up in his valley he knows nothing of the outer world. His daily life calls out the qualities which distinguish the natives of the Alps. These are above all things a conservative mind, a firm adherence to old customs and traditions, love of native land, dependence on authority, religion carried to superstition, simplicity, contentedness, endurance, daring, courage, boldness which often degenerates into quarrelsomeness, strength, activity, ingenuity. The broad valleys which open to the plains have never been inhabited by true mountaineers, and even the large valleys within the mountains, through which a constant stream of traffic now flows, are being affected by the levelling influence of our day, and the inhabitants are rapidly losing their peculiar characteristics.

The occupations of the inhabitants depend greatly upon the nature of their country. Many of the principal valleys are seats of different manufacturing industries; they are also the main centres of agriculture and cattle-breeding. As the dwellings and fields and gardens lie higher up the narrow valleys, the labour of man is modified accordingly. The cultivation of the fields, vineyards and gardens, and also the occupation of mining,

have generally their peculiar stamp, as may be imagined when the plough itself is carried over mountain slopes at a height of from 4270 feet to 6230 feet, and the miner descends his mine at a height of over 8500 feet.

The woodcutter fells the trees, which often hang over precipi-

Tyrolese Peasant.

tous cliffs, and then sends them down into the valley by means of the mountain torrents, or, if no torrent be near, on slides made of long tree-trunks, called "Holzriesen." The path of the mountain farmer lies over steep declivities, where no cattle, scarcely indeed sheep or goats, can be driven. The huntsman

follows his game through a jagged wilderness of rocks that threaten danger and destruction.

The mountain pastures, however, afford the principal occupation of the true mountaineer. These elevated pastures just below the snow-line are not capable of cultivation, but they furnish luscious food for the cattle, which are driven up to these so-called alps or alms at the beginning of the summer, and remain there in the fresh pure mountain air as long as the fine weather lasts. During all this time the herdsman (senne) lives in the senn-hut, which is composed of logs placed one upon another, the roof being weighted with large stones to prevent it being carried away by the wind. Here the milk is made into excellent cheese and butter. The latter is specially found in the Eastern Alps, in Austria and Styria, where women are generally employed in the tending of the cattle. The herdsmen and women are generally poor people, living on milk, butter-milk and thin cheese, with coarse bread, which is often not too plentiful. The departure with the cattle for the alp at the beginning of summer is a festival for the herdsmen and for the herd. The cows are decorated with flowers and ribbons and have bells round their necks, and are led by the herdsmen, uttering joyful shouts and cries. Not until he is on the mountains does he practise his peculiar song, the beautiful, melodious "Ranz des Vaches," or blow his Alpine horn. The mountain cattle-feeding is carried on most successfully in Switzerland, Tyrol, and Salzburg.

The costume of the native of the Alps is sometimes as original as his character. The accompanying illustration shows a peculiar kind of hat, which is worn by both sexes. It is of very varied form and colour, and is adorned with feathers and chamois beards; in some parts of the country it is of all colours mixed confusedly together, in others tolerably uniform. The usual dress of the Alpine man is a woollen coat of brownish grey cloth, which he weaves himself. In Switzerland, long trousers

are worn, while in the Eastern Alps, short leather breeches, stockings, which leave the knee bare, and stout shoes complete the costume. A leathern girdle surrounds the body, and the wide braces (usually green) cover part of the breast. The costume of the men in some of the Tyrolean valleys is picturesque, that of the "saltner," or vineyard-keeper, in the neighbourhood of Meran and Botzen, is very fantastic. The costume of the women in many neighbourhoods is less pleasing than that of the men, often indeed quite hideous, principally on account of the short-waisted bodice. There are neighbourhoods, however, in which the women's dress is very pretty.

Saltner, or Vine-watcher from Méran.

The natives of the Alps are usually of fine, stalwart form, though the women lose their beauty very early, probably on account of the laborious work they have to perform, but there is a great deal of disease and deformity among the natives of the gloomy, damp valleys. Recent researches have proved that this prevalency of deformity is greatest among the primitive mountains, and the diluvium of the rivers which have their sources among the primitive rocks, that it is very rare on limestone rocks, and that the greater amount is found in the valleys.

It is to a great extent hereditary, and is no doubt perpetuated by the intermarriage of near relations, which is usual in these isolated valleys.

Though the soil and air of their native land is thus fatal to the inhabitants, strangers seek and find within the borders of the Alps both bodily and mental health and vigour. This is due to the pure strengthening breezes which move over the mountains, the extreme mildness of the winter in some places, and the dryness and calmness of the air. Among the climatic health-resorts are the beautiful towns of the Riviera, Nice, Monaco, S. Remo, Mentone, also Geneva, Vevey, and Montreux, on the Lake of Geneva, Interlaken, between the Lakes of Thun and Brienz, Meran, Arco, and Riva in South Tyrol, Fusch in Salzburg, &c. The winter resorts high up among the mountains, Davos in the Grisons, St. Moritz, Samaden, Pontresina, Zug in the Engadine, are becoming more and more frequented. In addition to these may be mentioned the numerous mineral springs which are found all over the Alps.

The dwellings among the Alps are generally of the type known as the Swiss house, square in form, with flattish overhanging roof, and outside balconies and staircase. In addition to the towns, there are villages, hamlets, and single homesteads. The latter are found exclusively high up among the mountains, and in many parts of the country they are situated on the shady side of the valleys, while the villages are placed on the sunny side.

The many dangers by which they are daily surrounded, and the constant conflict with the forces of nature, make the Alpine natives observant and full of resources, and consequently easily trained in the knowledge of science and art, in every branch of which they have been distinguished. The beautiful wood-carving of the Tyrol is well known, and the Alps have also produced many sculptors, painters, and musicians whose fame has spread far beyond their native mountains.

## CHAPTER XVII.

### ALPINE ROADS AND RAILWAYS.

THE many ramifications of the Alps offer natural facilities for the formation of roads, and consequently this range is, perhaps, more accessible than any other high mountains in the world. The roads may be divided into longitudinal and transverse roads and passes.

A longitudinal road runs through a longitudinal valley, leading from it to a neighbouring longitudinal valley continuing in the same direction. Such roads have rarely any obstructions to overcome, except such as are offered by marshy land or occasional ravines, or by periodical inundations.

A transverse road is one which forms a means of communication between two important parallel valleys, either by using a collateral valley, with the help of its stream, to reach a joch in the crest of the watershed, or by immediately penetrating a transverse valley of the principal chain. In either case, the nature of the collateral and transverse valleys causes many obstacles to occur, which can only be overcome by the construction of roads at great expense and with much difficulty. By such roads the upper ravines are reached, which lead up to the crest, and it is here that the actual pass begins.

The Alpine passes are the highest and most difficult passages over the crests which constitute the watersheds, and form the shortest means of communication between two opposite valley systems. The pass-valleys which lead up to the mountain crest itself, are often only gloomy ravines, which inspire fear, with their overhanging cliffs, wild torrents, hanging glaciers, and

terrible storms. They can be avoided only by a dangerous clamber over deceptive slopes of *débris*, or narrow ledges of rock, or at night over the frozen snow which covers deep chasms. The roads, which are made in numerous zigzags, have been constructed by the aid of much blasting, and the erection of high dams as a protection against the violence of the torrents, with stone bridges, and long covered galleries as a shelter against avalanches and falling stones, which are sometimes driven down by the hurricane and fall over with a sound as of thunder into the yawning chasm below. Thus the upper valley of the pass is reached; it is often an important depression of the crest, which is fortunately found just where the inner ends of two valleys running in opposite directions meet. The upper valley of the pass is usually from half a mile to two and a half miles in width, and is often from three to eight miles long, and is level, or has only a slight inclination.

In the middle of its usually bare space, and near the limit of perpetual snow, the last human habitations are found; a hospice, an inn, or even a tiny village under the shelter of the cliffs. From the highest part of this elevated valley-cauldron, the road leads down on the opposite side, under much the same conditions as it ascended, into the valley of another river, into another landscape, often into another state, among people with other customs and speaking another tongue. On the Italian side the descent is much shorter and steeper.

The road over the mountains may be a footpath, a bridle-path, a driving-road, or a high road, according to the amount of traffic, and the means of transit, and in recent times railways have also been constructed.

There existed roads over the Alps as early as the Roman period. Polybius, writing in the second century A.D., mentions four Alpine roads, which were then in use: the *Alpis maritima* on the Ligurian coast, the *Alpis Graja* (the Little St. Bernard), the *Alpis Penina* (the Great St. Bernard), and the road through

Rhætia (over the Brenner). Pompey probably opened the road over the *Alpis Cottia* (Mont Genèvre). According to the itinerary of the Empire there were, in addition to these, the following roads: the two Rhætian roads over the Splügen and the Julier, the two Carnic roads over the Plöken (Monte Croce) and over Pontafel-Tarvis, and the Julian road. Besides these, Roman high roads were known to exist over Mont Cenis, St. Gothard, the Simplon, and the Reschen-Scheideck. The Roman military roads (*viæ stratæ*) were firmly constructed, with cuttings in the rock, dams and bridges of solid masonry, and walls, the plans for which must have been carefully prepared by the Roman architect, with a knowledge of all the local conditions of streams, the position of the snow, the courses of the avalanches, the effects of weathering, exceptional storms, and the advantages of the sunny side over the shady side with its heavy masses of snow. One of the most important high roads over the Alps was the Brenner road, from Verona to Augsburg, which was opened by the Emperor Claudius A.D. 46, and was thence called the *Via Claudia Augusta*. It passed from Verona through the valley of the Adige, past *Tridentum* to *Pons Drusi* (at Botzen). As the valley of the Eisak, above this point, presented an apparently inaccessible gorge, endeavours were made to find a way northwards over the mountains right and left of it. One of these side-roads led through the Talfer valley over the Ritten to Waidbruck, the other over the Seisser and Kastelruther mountains to Seben. The road again followed the course of the Eisak to *Sebatum* (Franzensfeste), and ran past Sterzing (*Vipitenum*), Pfons and Matrei (*Matreium*) to Wilten (*Veldidena*) on the Inn. From this point it turned into the valley of the Inn, passing up it as far as Zirl, then over the Scharnitz (*Scarbia*) to Partenkirchen (*Parthanum*), and over into the valley of the Lech, and down the Lech to Augsburg. A road also went along the Inn from *Veldidena* to Passau (*Batava Castra*). After

the Roman dominion in the Alps was overthrown, the Brenner road, which the Romans had constructed, continued through the whole of the Middle Ages to form the chief connection between Germany and Italy. The Roman emperors of the German nation passed along it to Italy, whence it received the proud title, "the Kaiserstrasse."

The following is a list of the Alpine passes which are at present of the most importance :—

*A.* Passes over the Western Alps :—

1. The road over the Bocchetta Pass (2558 ft.) from Genoa and Pontedecimo to Novi, and in the Valley of the Scrivia.

2. The high road over the Col di Tenda (6142 ft.) between the Ligurian coast and the Stura, from Nice to Coni.

3. The road over the Col de Mont Genèvre (6100 ft.) between the valley systems of the Durance and the Po, from Briançon to Turin.

4. The road over the Col de Lauteret (6806 ft.) from Briançon on the Durance, and in the Romanche Valley, to Grenoble.

5. The high road over Mont Cenis (6882 ft.) between the valley systems of the Isère and the Po, up the Isère from Grenoble, and then up the Arc to the Dora Riparia and Susa.

6. The difficult driving-road over the Col of the Little St. Bernard (7075 ft.), between the valley systems of the Isère and the Dora Baltea, being in its first portion the high road from Grenoble, and also from Chambéry up the Isère as far as Moutiers, from there a carriage-road as far as St. Maurice, and with difficulty to the Dora Baltea, and from there to Aosta.

*B.* Passes over the Central Alps :—

1. The pass (bridle-path, but with approaches for vehicles) over the Great St. Bernard (8108 ft.) between the Rhone and the Dora Baltea, from Martigny to Aosta.

2. The Simplon Pass (6593 ft.) between the Rhone and the Ticino, the high road from Brieg to Sesto Calende (on the Tosa to Lago Maggiore).

3. The bridle-path over the Grimsel Pass (7101 ft.) from the top of the Rhone Valley, into the Aar Valley.

4. The road over the Furca Pass (7990 ft.) from the Rhone Valley, into the Ursern Valley.

5. The St. Gothard Pass (6934 ft.) between the Reuss and the Ticino, the high road from Flüelen, on the Lake of Lucerne, to Lugano and Como.

6. The high road over the Lukmanier Pass (6286 ft.) from Dissentis on the Vorder Rhine, through the Middle Rhine Valley into the Breno Valley.

7. The St. Bernhardin Pass (6766 ft.) between the Rhine and the Ticino, up

the Rhine from the Lake of Constance through numerous ravines, through the Via Mala on the Hinter Rhine, forming the high road over to the Misox Valley and to Bellinzona.

8. The Splügen Pass (6943 ft.) between the Rhine and the Adda. Formerly the road to the Hinter Rhine, and to Splügen in the Rheinwald Valley, then over into the Val St. Giacomo, past Chiavenna, to Riva on the Laghetto di Mezzola.

9. The high road over the Maloja Pass (5940 ft.) from the Upper Engadine into the Bergell Valley.

10. The high road over the Bernina Pass (7656 ft.) from Samaden, in the Upper Engadine, to Tirano in the Valley of the Adda.

11. The boundary Pass of Finstermünz, a wild fortified ravine, through which the Inn flows out of the Swiss Engadine into Tyrol. The fine new road through this pass was completed in 1855.

12. The high road over the Stilfer Joch (Stelvio, 9174 ft.), the highest Alpine pass available for vehicles, between the Etsch and the Adda, from the Vintschgau into the Veltlin. This remarkable road was completed in 1820-24; it ascends from Trafoi in forty-six zigzag turns, the last of which is partly in covered galleries, to the top of the pass, and then descends in thirty-eight turns to Bormio.

13. The Reschen Scheideck (4909 ft.), between the Inn and the Etsch, the high road from Finstermünz to Glurns.

## *C.* Passes over the Eastern Alps:—

1. The Arlberg Pass (5893 ft.) is crossed by a road which leads from Landeck on the Inn through the Stanzer Valley, over the top of the pass into the Kloster and Ill Valleys and to the Rhine.

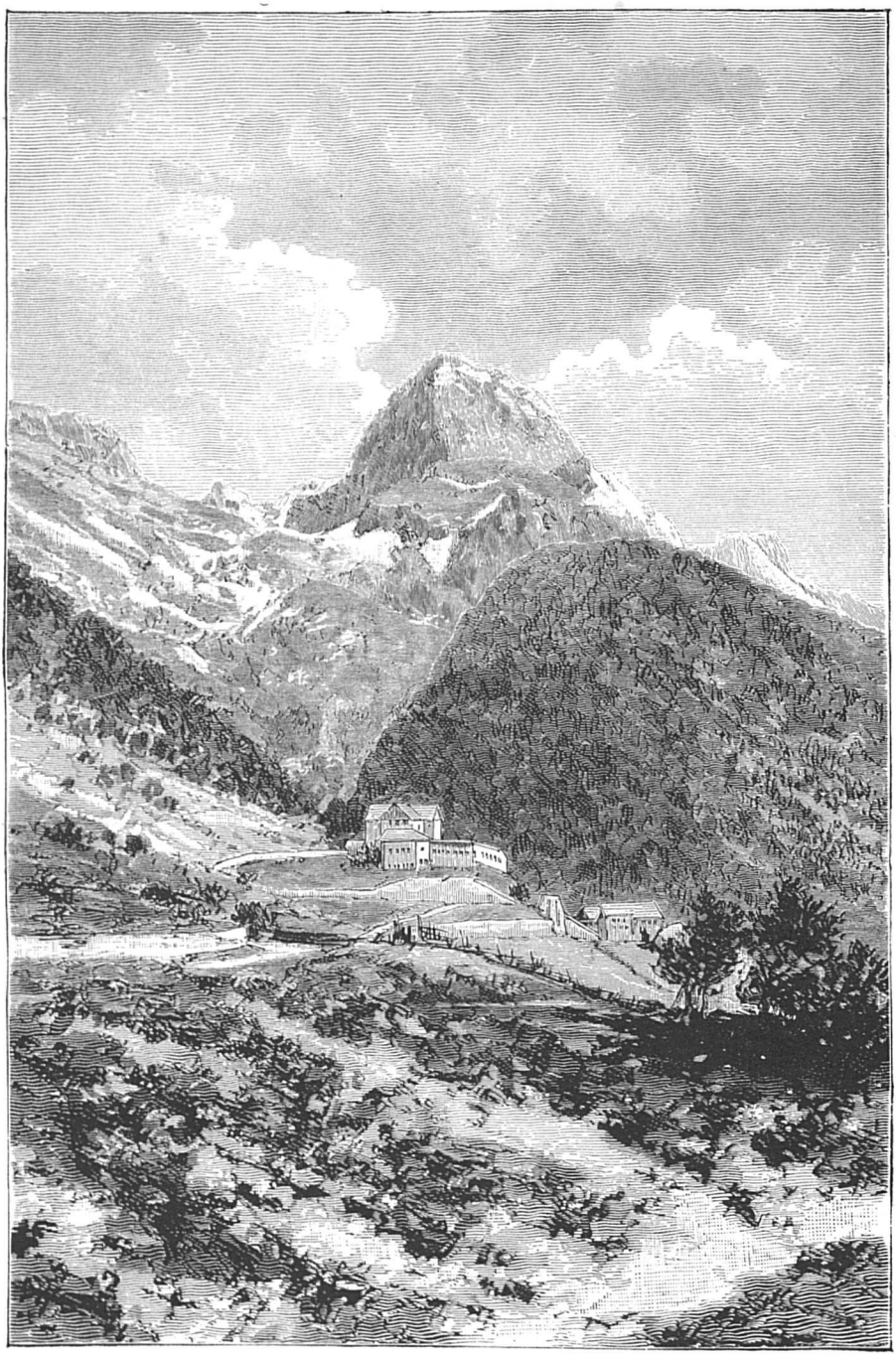
2. A high road leads from the valley of the Inn, through the Fern Pass (3958 ft.) and the Ehrenberger Klause (3620 ft.), to Reutte on the Lech, and a second road goes over the Seefeld Pass (3856 ft.) and the Scharnitz Pass (3158 ft.) to Mittenwald on the Isar.

3. The Brenner Pass (4466 ft.), between the Inn and the Eisak, the high road from Innsbruck to Sterzing, Brixen and Botzen, and farther on to Italy.

4. The Pass Lueg extends in the form of a ravine nearly eight miles long, between the Tennengebirge and the Salzburg Alps, on the Salzach, leading from Salzburg to Werfen.

5. The Malnitzer Tauern (7917 ft.) is the oldest of the bridle-paths that lead over the Hohen Tauern, between the Upper Salzach and the Drave, and is at the present time also the most convenient, on account of the splendid high road from Salzburg through the Pass Lueg to Lend, and from there through the Pass Klamm, in the Gastein Valley, as far up as Böckstein; on the other side the road from Malnitz is connected with the Drave by means of the Möll Valley.

6. The Radstädter Tauern (5700 ft.) and the Hoch Feld Pass, between the valley systems of the Enns, the Mur, and the Drave, high roads from Radstadt on the Enns to St. Michael on the Mur, and thence over the Katschberg (5483 ft.) to Spital at the mouth of the Lieser on the Drave.



The Mangart Group, seen from the Predil.

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7. The Rottenmanner Tauern (4140 ft.), between the Enns and the Mur, the high road from Liezen to Judenburg, and thence over low saddles to Klagenfurt.

8. The Prebichl or Eisenerze Tauern (4024 ft.), also between the Mur and the Enns, the high road from Leoben, past Vordernberg, to Eisenerz and Hieflau.

9. The Pyhrn Pass or rather Pyhrn Klause (3099 ft.), between the Enns and the Danube, from Liezen to Windischgarsten and Steyr or Wels and Linz. Past Steyr, through the Gesäuse (the breach of the Enns) and past Hieflau, as far as Kloster Admont, then up the whole length of the Palten Valley, over the flat saddle of the Walderhöhe (2772 ft.), down the Liesing Valley to St. Michael, and in the Mur Valley as far as Scheifling.

10. The Cristallin Pass, between the Puster Valley and the valley of the Piave, the high road from Toblach, through the Höhlensteiner Valley to Cortina, in the defile of the Ampezzo and Piave Valleys.

11. The Pass Pontebba or Pontafel (2655 ft.), between the Drave and the Tagliamento, the high road from Villach, goes up the Gail, past Arnoldstein, Tarvis, Pass of Saifnitz, through the defiles of the Fella (a left affluent of the Tagliamento) and the Chiusa Veneta at Pontebba, to the Tagliamento and to Udine.

12. The Predil Pass (3811 ft.) between the Drave and the Isonzo. The above-mentioned high road as far as Tarvis, and then into the Isonzo Valley to the Flitscher Klause, and down the valley to Görz.

13. The Wurzener Pass (3511 ft.), between the Drave and the Save, from Tarvis again, but only a by-road into the Save Valley, then the high road down the valley to Laibach.

14. The Loibl Pass (4492 ft.), also between the Drave and the Save, the high road from Klagenfurt southward, past Hollenburg, and across to Neumarktl, Krainburg, and Laibach.

15. The Semmering Pass (3214 ft.), the lowest of the important Alpine saddles, the new high road which connects Schottwien with Mürzzuschlag, and in its farther extension, Vienna with Graz and Trieste; constructed in the years 1839-42.

The following are the most important of the longitudinal passes:—

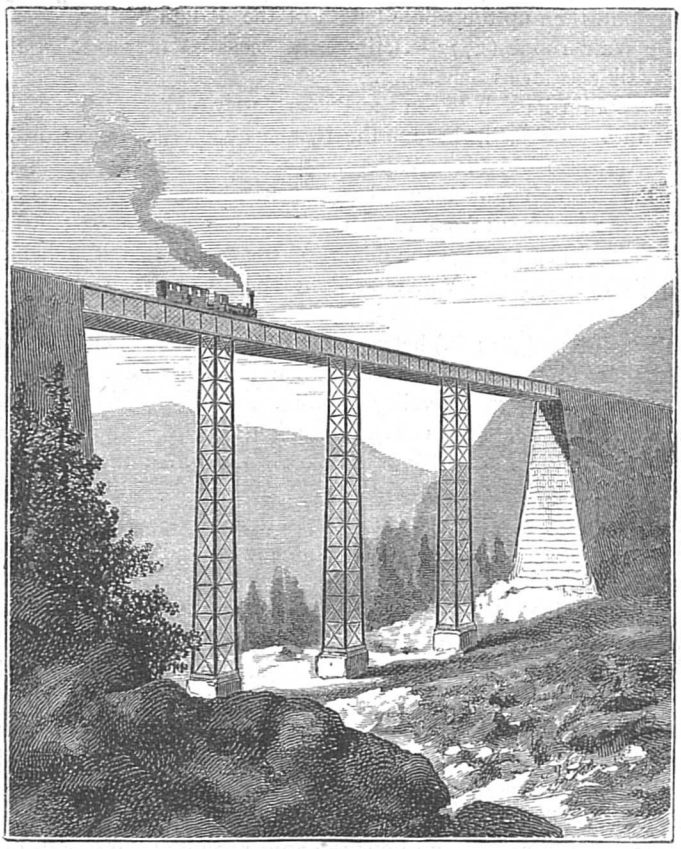
1. Through the upper valley of the Rhone, over the Furka Pass, into the Ursern Valley, and hence over the Oberalp Pass into the valley of the Vorder Rhine, down the Rhine Valley, from there to Lake Constance.

2. A second line of connection joins the above route at the mouth of the Ill; it leads through the valleys of the Ill and Kloster to the Arlberg Pass, crosses this into the Stanzer Valley, and goes from Landeck, down the Inn, to the Bavarian plateau.

3. A connecting route goes from the lower valley of the Inn, through the Ziller Valley and the Gerlos Valley, over the Gerlos Pass (here only by a bridle-path) into the valley of the Salzach, then over the Wagreiner Höhe into the valley of the Enns (through the Mandling Pass), from the Enns Valley either through the Palten Valley, over the Walderhöhe and through the Liesing Valley

into the valley of the Mur, or through the valley of the Styrian Salza, over Wegscheid and the Nieder Alps to Mürzsteg, and down the Mürz Valley to Mürzzuschlag.

4. A route leads from Finstermunz in the valley of the Inn, through the transverse valley of Nauders to the Reschen Scheideck, then through the valley of the Etsch to Botzen, thence up the Eisak as far as Brixen, through the Rienz Valley, across the Toblacher Feld, and then down the Drave Valley to Warasdin.



On the Rhigi Railway.

The modern means of traffic, the railway, has invaded the Alps, and, since the completion of the Semmering railway showed the possibility of constructing a mountain-railway on a grand scale, the number of lines has constantly increased. The construction of these railways has completely changed the con-

The Spiral Tunnel at Waffen, on the St. Gothard Railway.

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ditions of traffic on all the main routes; passengers and baggage being carried by them to most of the principal places, while the beautiful high roads are now used only for local traffic and by tourists.

The construction of the Alpine railways offered enormous difficulties, which, however, have been victoriously overcome. The necessity of obtaining a uniform gradient, of protection from snow-drifts, avalanches, falling rocks, landslips, and other dangers, all had to be taken into account. The ascent is performed by taking a roundabout route, winding through collateral valleys or spiral tunnels (Kehr-tunnels) from one stage to another, or by tunnelling for a long distance through the mountains.

The first of the great Alpine railways was the Semmering, as already mentioned; this was followed by the railways over the Brenner, Mont Cenis, the St. Gothard, and the Arlberg.

The four largest tunnels are the Semmering Tunnel (1557 yards long, 2949 feet above the sea), the Mont Cenis Tunnel (13,334 yards long, 4579 feet above the sea), the St. Gothard Tunnel (16,254 yards long, 3785 feet above the sea), and the Arlberg Tunnel, (11,182 yards long, 4300 feet above the sea).

A cog-wheel railway has been constructed on the Rhigi, connecting Vitznau on the Lake of Lucerne with Rhigi Kulm, and ascending 4463 feet. Another railway of the same kind has been made on the Kahlenberg at Vienna. On some other mountains having less slope, mountain railways without the cog-wheel system have been made, and on those that have a greater slope ropeways are sometimes used.

## CHAPTER XVIII.

### ALPINE LORE AND ALPINE TRAVEL.

THE Alps have their history in another sense than that of their geological formation, and their culture and civilization; they have also a history of discovery, climbing, and travel. This begins only in recent times, although the knowledge of the Alps has gradually developed in the course of two centuries.

Looking back to the earliest records of knowledge of the Alps, we begin with the Greeks, and find that Herodotus knew simply nothing of them, Aristotle not much more, and that Eratosthenes possessed only a very meagre notion of them. Polybius undertook a journey through the Western Alps in order to be able to describe Hannibal's passage, and was acquainted with the tract of country from Marseilles to the Adriatic. The Alp country was in a very great measure open to the Romans in the time of Augustus, forty-four of the mountain tribes being at that time subject to Rome, and the Alps and their inhabitants are frequently mentioned by the poets and historians of that period. The first, though not very satisfactory, geographical description of the Alps, is that of Strabo. Among the Greek writers, one Roman may, be named, who, uniting all the collective knowledge of his time including that of geography, in one great work, gave a more animated picture of the Alpine country; this was the elder Pliny. He not only treated of the topography and ethnology of the Alps, but also described the conditions of climate, and the *flora* and *fauna* of the high mountains. Ptolemaus gave a brief statement of the different pro-

vinces, towns, and rivers of the Alps, while the contemporaneous itinerary of Antoninus gives information respecting the military roads through the Alps and their stations. Since the time of Antoninus the Eastern Alps especially have been the scene of great military events, but the works of the historians are very poor in geographical details.

In the middle ages, as with the ancients, the historians treat in the first place of geographical matters. Thus the letters of Cassiodorus contain topographical accounts of the Central and Eastern Alps, while the Western Alps, then disturbed by great military movements, form the principal subject which occupies the attention of Gregory of Tours. Paul Diaconus interlards his history with short geographical descriptions relating to the Alpine district, such as those of the Cottian and Ligurian Alps.

The cursory remarks of Prokopius on the Alps are somewhat hazy, while Jornandes here and there enters more into detail, describing both country and people at some length. Another source of geographical information lies in the biographies of Christian missionaries and the records of pilgrimages. But all these writings contain simply topographical data, and the same may be said of the histories of the passages over the Alps made by the German kings. The Alps also take a more or less modest position in the maps of the period, as in those of the Venetians, Andrea Bianco and Fra Mauro. The Arabs, whose knowledge of the geography of the middle ages was exceptionally good, have very little to say on the subject of the Alps. Edrisi's map is a very maze as regards the European Alps, and Abulfeda dismisses the whole range with a few words.

It was little better in the sixteenth and early part of the seventeenth century, the scientific men of the time contenting themselves with identifying the places and tribes of the ancients. In the second half of the seventeenth century, however, increasing efforts were made to know and describe the Alps, and their

natural features, from a purely scientific point of view. The numerous wars under Maximilian I. and Charles V. contributed to a closer acquaintance with the Alps, and the revival of Art, especially as regards map-drawing, gave an extraordinary impetus to geographical science.

Only a few of the most important workers on this subject can be mentioned here.

During the sixteenth century the most distinguished writers on the Austrian Alps were John Cuspinianus and Wolfgang Lazias, while the physician, Theophrastus Paracelsus, specially treated of Carinthia. For the topography of Tyrol, George Kirchmayr, Janus Pyrrhus Pincius, and Marx Sittich, Baron of Wolkenstein, are the most important. Aventinus drew an interesting map of Bavaria in 1523, but the most important geographer of Bavaria is Apianus. Vadian, Glarean, and especially Aegidius Tschudi and Conrad Gessner may be called the fathers of Swiss geography, indeed the latter was perhaps the first great Alpine specialist. He was the first to point out the characteristics of the Alpine plants, and to divide the Alps into regions, as regards their climate, flora and fauna. Of the Italians of the sixteenth century, Paulus Jovius, the historian, is worthy of mention; he described, several of the passages across the Alps, and gave an excellent account of the Lake of Como. Maginus and Jacopo Gastaldi were map-draughtsmen. Even in the sixteenth century France had a number of "royal geographers," some of whom devoted considerable attention to the Alp countries, such as Orontius Finnæus, Jean Jolivet and Peter Bomparius.

Descriptions of travel were fairly numerous in the sixteenth century, all of which show that the Alpine passes were got over as quickly as possible as an unpleasant necessity. The middle of the century was marked by the appearance of maps and of practical guide-books, which were generally published by physicians.

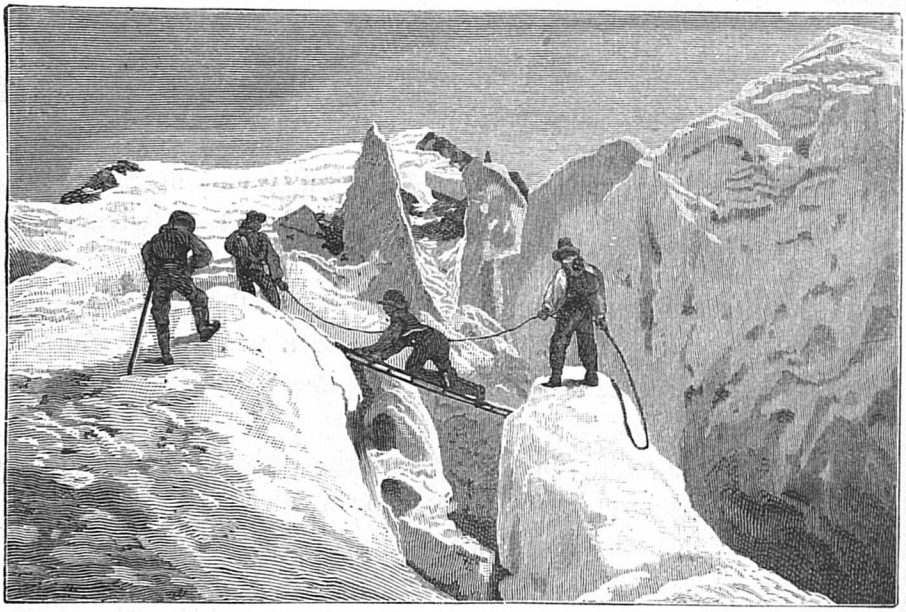
The most famous geographer of the seventeenth century,

Philip Cluverius, described the Alpine country he had himself travelled through, in his books entitled, "Italia Antiqua" and "Germania Antiqua." Hieronymus Megiser was an important writer on Carinthia, but Valvasor was still better known. Tyrol was especially rich in geographers and map-makers, in this century. Bavaria, on the contrary, was very poor. In Switzerland some descriptions of separate places began to be published, such as the map of the Canton of Zurich, by J. Gyger. The principal work on the western portion of the Italian Alps was the "Theatrum Subaudiæ (1682); Coronelli's "Atlas Veneto" was the chief work on the eastern part. Tavernier, who travelled a great deal, considered the view from Geneva towards the Savoy Mountains as the most beautiful he had seen, and in Sanson d'Abbeville's "Atlas" we find the "glacières" given, but seek Mont Blanc in vain. The number of books of travel continued to increase in the seventeenth century, but the journeys were made through the Alps not in them. Matthäus Merian (1593—1650) represented several Alpine landscapes in his illustrated works.

The first who stands pre-eminent in the eighteenth century is Balthasar Hacquet (1740—1815), who travelled through a part of the Alps which he looked at with the eyes of a true explorer, and afterwards described what he had seen. There were besides a large number of local historians in Austria who did good service in describing the topography of the Eastern Alps. Homan, Seutter, and the two Tyrolean peasants, Anich and Hueber, were well known as map-makers.

In Switzerland, Scheuchzer (1672—1733) was the first of a series of scientific Alp explorers, and opened a new era with his works, "Οὐρεσιφοίτης, sive Itinera alpina tria," and "Natural History of Switzerland." In 1740, the English travellers, Pocock and Windham explored the valley of Chamounix, and soon after books appeared on glacier observations in Savoy and Switzerland, by Martel, Altmann, Grüner and Bourrit. The best-known

name among the Alpine explorers of the last century is that of Horace Benoit de Saussure, of Geneva, the discoverer of Mont Blanc. In his "Voyage des Alpes," he marked out the path in which Humboldt and the later Swiss geologists followed. The mineralogy, the botany, and geology of the Alps, all soon found their workers. The best maps were those of Raymond, Delisle, Cassini, Villaret, and a few others.



Tourists on the Grindelwald Glacier.

Great progress may be observed in the eighteenth century with regard to works of travel. Men began to travel with definite scientific or artistic aims, to leave the beaten tracks among the Alps, and despising the danger, began to approach the higher Alpine regions which had previously been closed to them. A glance at the history of the exploration of the Alps, will show that it was the botanists who first made their way into the upper mountains; they were followed by the entomologists, and later on by the geologists. Last of all, in our own cen-

tury, the orographer appeared, for whom the true fundamental knowledge of the mountains was reserved. By systematic division of labour, the geological and plastic conditions, the climate and glaciers, lakes and glacial formations, flora and fauna, ethnology and history, were made the subjects of exhaustive researches, and the most important results for science were obtained. Trigonometrical measurements, the establishment of meteorological stations, a number of Alpine tours undertaken in the interests of science, and excellent maps, have extended and rectified our knowledge. In fact, Alpine lore has risen almost to the rank of a science.

The increased attention to natural science and geography in schools, and the improved means of transit, have called forth an intense love of Alpine travel, which, beginning in England, has gradually spread to the Continent. The tendency of our time to association for all sorts of purposes, has also borne fruit as regards the exploration of the Alps, and led to the formation of Alpine Clubs. The English Alpine Club came into existence in 1857; since that time, twenty others have been formed, in Austria, Switzerland, Germany, Italy, France and Belgium, their object being to examine the Alps more closely from the point of view of topography and of physical geography, and to facilitate travelling in them. These Alpine Clubs, now numbering altogether about 50,000 members, have attained considerable importance at the present day, and though all the members may not be attracted to the mountains by an equally scientific spirit, it must be acknowledged that their journals, year-books, guides, panoramas and maps, have materially promoted a knowledge of the Alps. And more than this. By building huts and shelters in the upper mountains, observatories on the peaks, and by making paths, they have greatly facilitated travelling in the Alps, not only for their own members but for the world at large. A great many of the needy natives of the country are employed in ministering to the wants of the large

number of persons who now frequent the Alps, and thus the prosperity of the neighbourhood is increased. The activity of some of these clubs, too, in re-foresting some parts of the mountains must not be undervalued, nor the element of cultivation which they bring into the remote mountain-valleys.

To the climbers themselves, apart from any scientific knowledge which they may acquire, the advantages of their mountain pursuits are incalculable, in the training of eye and limb, the acquirement of habits of endurance, courage, and self-control, and that increased largeness of soul which is the natural result of close communion with Nature in her grandest form.

THE END.

# INDEX OF PLACES, MOUNTAINS, RIVERS, &c.

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